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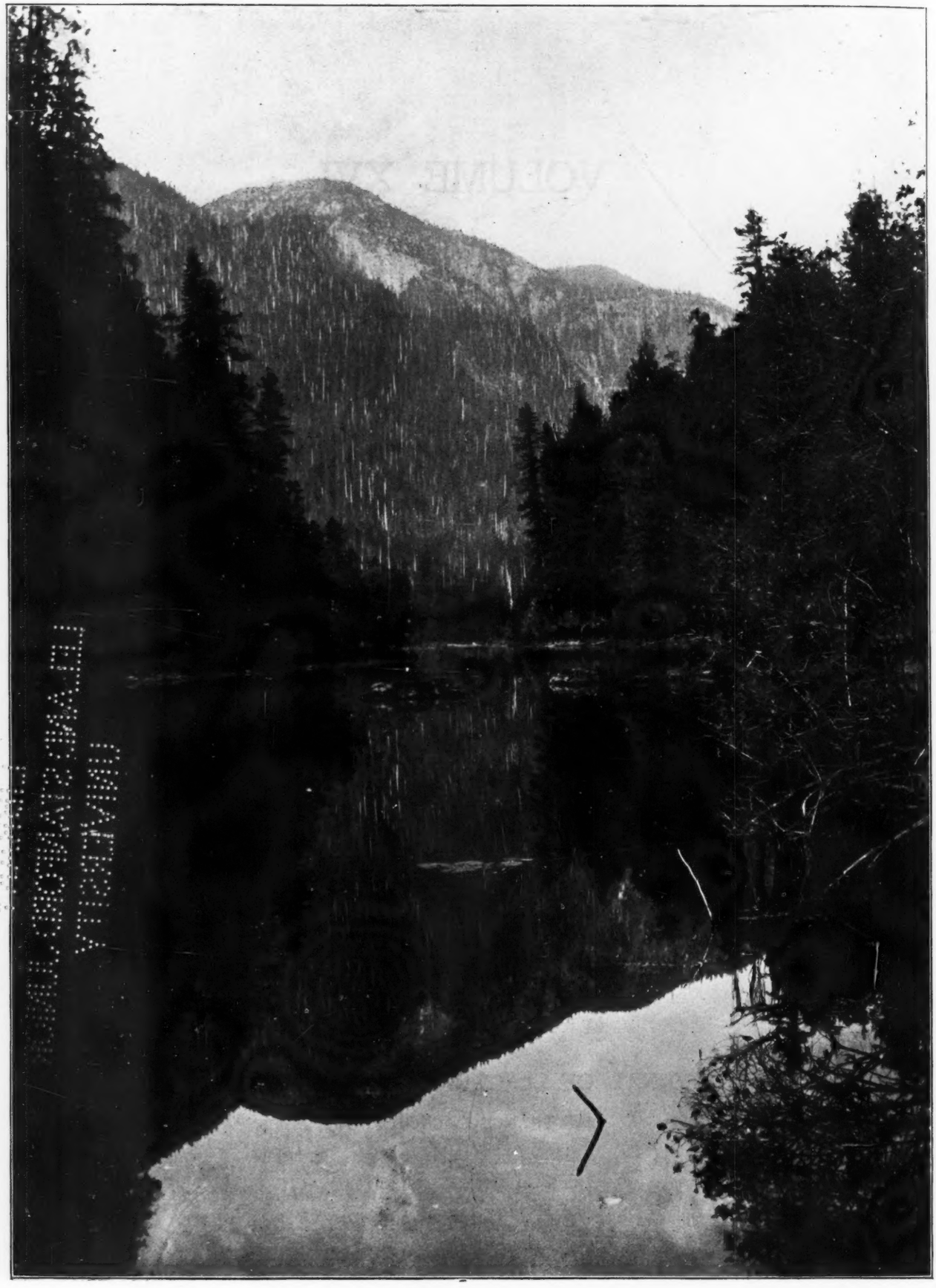

COQUITLAM LAKE OUTLET. TUNNEL MOUNTAIN IN THE DISTANCE

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The Plant of the Vancouver Power Company (Ltd.)

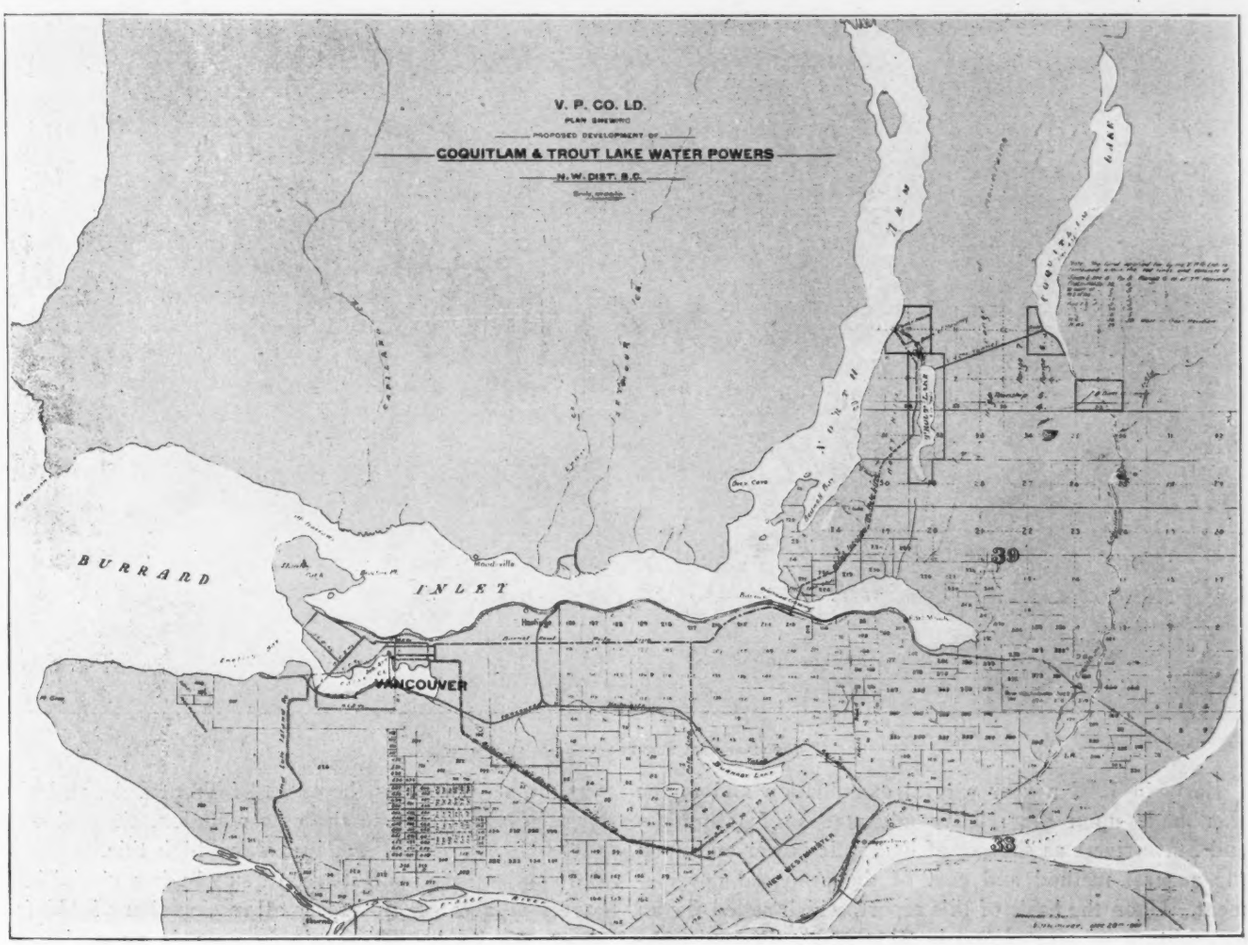
BY WYNN MEREDITH

THE birth of Vancouver, British Columbia, may be said to date from the building of the Canadian Pacific Railway and its extremely rapid growth to a city with a population of over forty thousand marks an era in the history of the marve'ous development of the Pacific Coast.

Situated on the eastern shore of the island-protected waterways characteristic of the North Pacific, surrounded by mountain ranges towering four to seven thousand feet above sea level, a magnificent harbor and the terminus of a trans-continental railway,—small wonder that Vancouver has prospered and grown.

In keeping pace with the rapidly increasing demand for power, light and street car service, the electric interests in Vancouver at length found a limitation to the numerous additions to their original steam plant. In the course of a few years one unit after another had been installed until many different types and sizes of machinery were represented in the power station.

While a large quantity of some of the finest steam coal on the coast is mined within sixty miles of Vancouver and notwithstanding the fact that the city has every natural advantage for obtaining a good supply of coal at reasonable rates, monopoly decrees otherwise and in consequence at an early date investigations of the possible sources of hydraulic development in the neighboring mountains were commenced. Measurements of three available streams, Lynn Creek, Coquitlam and Stave Rivers were taken at intervals but, owing to the very large investment required for the development of

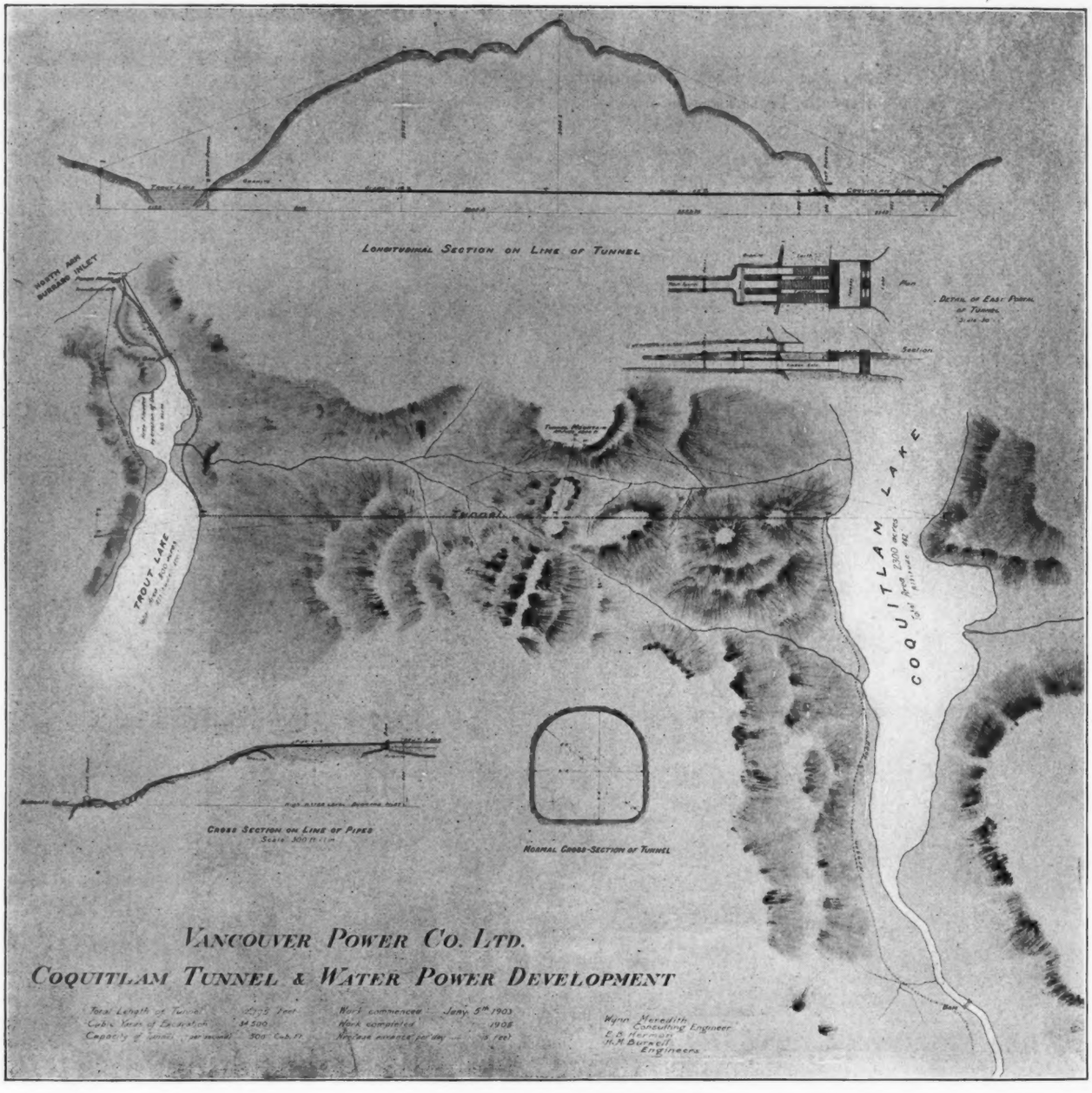


MAP OF DISTRICT SERVED

hydraulic power on any one of them and the comparatively small market afforded by the city of Vancouver, ten years elapsed before threatened competition awakened the electric interests to the necessity of taking immediate action as a measure of self protection. Not until this time were the wonderful possibilities of development, exemplified in the present plant of the Vancouver Power Co., Ltd., fully realized.

way Co., representing the electrical interests in Vancouver, and on the 15th of August, 1902, construction was commenced.

Reference to the accompanying maps makes clear the general plan of the development, the chief features of which are the dam at the outlet of Coquitlam Lake for the diversion and the creation of storage, a tunnel connecting Coquitlam with Trout Lake and serving as a water

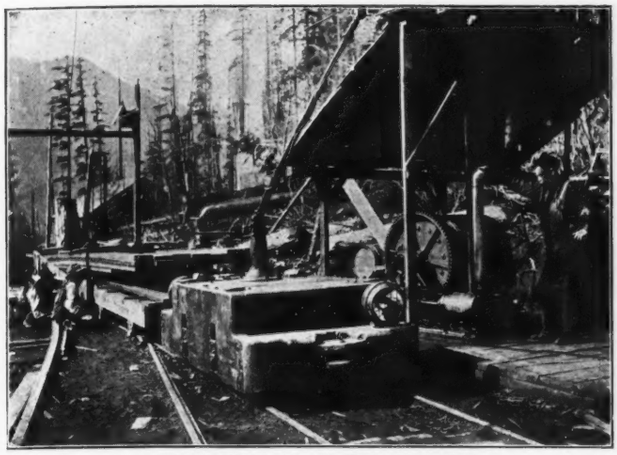


TOPOGRAPHICAL SURVEY MAP OF DEVELOPMENT

Early in 1902 a very careful examination and report was made upon the relative advantages of Coquitlam and Stave rivers as sources of hydraulic power and upon the general method and cost of the proposed development. Upon the basis of this report, which called for an expenditure of approximately $1,000,000, the undertaking was financed by the British Columbia Electric Rail-

conduit, a dam across the outlet of Trout Lake and pipe lines from this dam to the power station, situated on a navigable arm of the sea, just above high tide.

Coquitlam, the main source of supply, is a glacial lake, having an area of 2300 acres at an elevation of 432 feet above sea level. The drainage area is approximately 100 square miles, and the annual precipitation over this

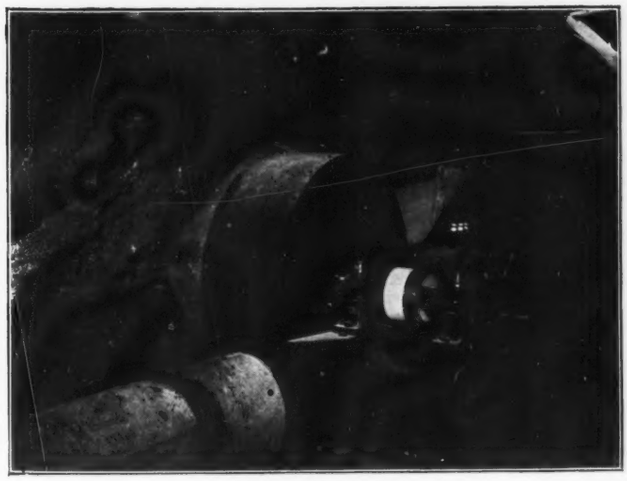


INCLINE HOIST AND ELECTRIC LOCOMOTIVE

area is about 150 inches. Measurements of the flow taken at the outlet of the lake over a period of thirteen years show that the lowest stage of water ever recorded occurred in September, 1904, when the flow was 300 cubic feet per second for a period of nearly fifteen days, gradually increasing until on November 30th the flow was 5000 cubic feet per second.

Trout Lake, used as a balancing reservoir at the head of the pipe lines, is separated from Coquitlam by a mountain range rising 4000 feet above its waters and the horizontal distance between the two nearest points of the two lakes is 12,775 feet, or nearly two and one-half miles. the lake is situated close to the north arm of Burrard Inlet and is distant about sixteen miles from the city of Vancouver. Its area is approximately five hundred acres and its elevation above sea level 400 feet, making the difference in elevation between Trout and Coquitlam lakes exactly thirty-two feet.

Owing to the steep, rocky slopes and perpendicular cliffs of the mountains separating the lakes, it was found impractical to carry the line of levels over the range and accordingly four series of levels were run from portal to portal of the proposed tunnel, a distance of twenty-five miles around the end of the range with the remarkably small maximum variation of 0.23 foot, determining the difference in elevation of the two lakes.



TUNNEL VENTILATING SET

For the alignment of the tunnel a Buff transit was used, having a large, high-power telescope. The instrument proved most satisfactory and no trouble was experienced in setting points 9300 feet distant. For convenience in communicating between the different stations, three signal men from the local militia were employed, using flags and the usual code, which method was found to be a great aid.

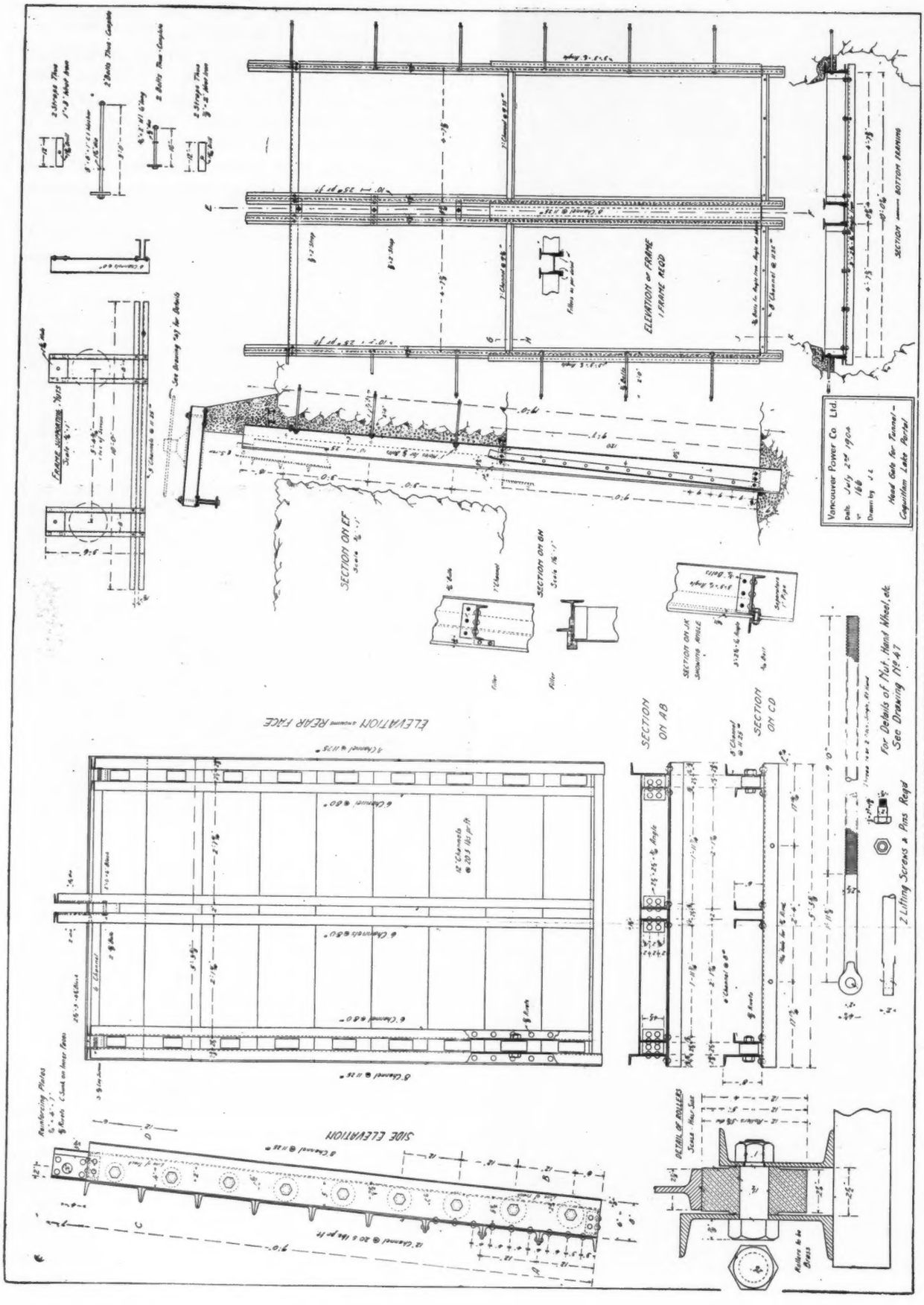
Four stations were established, of which two were on the mountain, 3200 feet apart, one on the further shore of Coquitlam Lake and one on the further shore of Trout Lake. From the station on Coquitlam Lake to the summit of the mountain the distance is 7901 feet, from the summit to the lower station on the mountain 3203 feet, and thence to the Trout Lake station 6170 feet. Owing to the contour of the mountain sides, neither tunnel portal could be seen from the stations on the range and it was therefore necessary to produce the alignment back across the lakes.

CONCRETE DAM

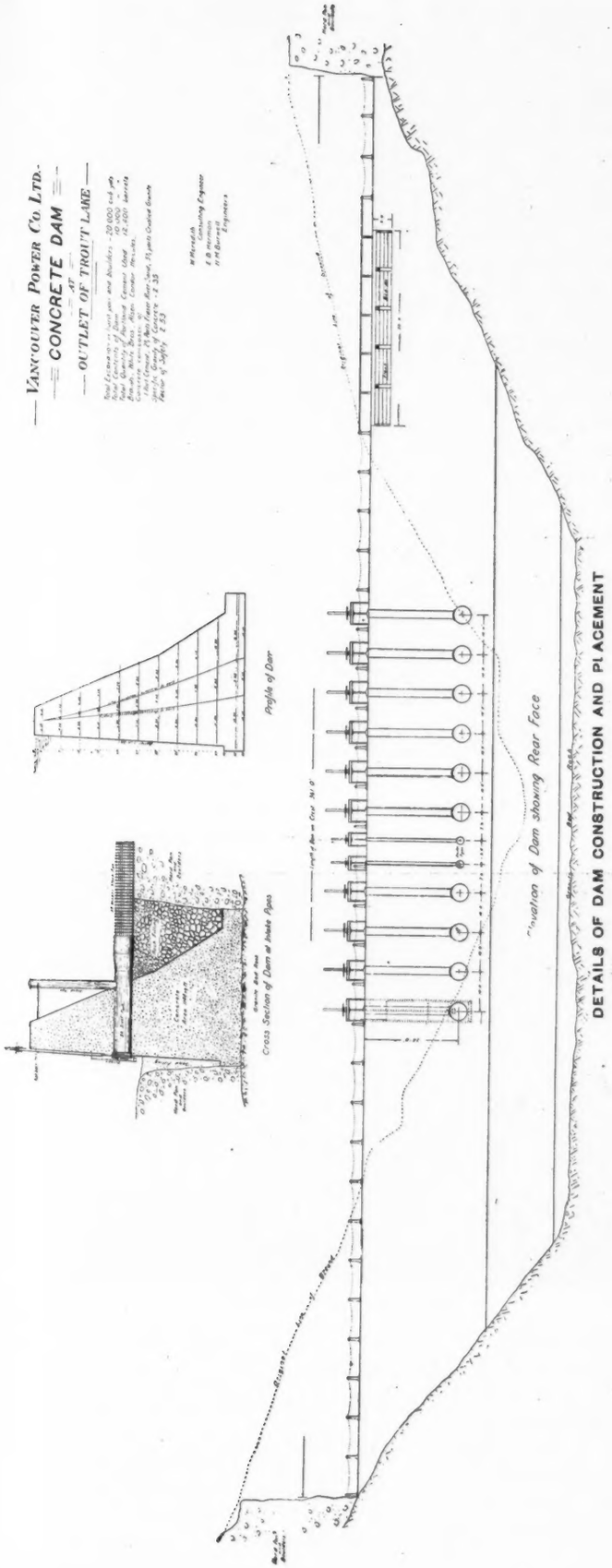
In August, 1902, temporary camps were established at each portal of the tunnel and work of clearing the extremely heavy timber commenced. During September open cutting at the portals was carried on by driving temporary headings through the gravel and clay deposits and then breaking down from above. At the Trout Lake heading solid rock was found at a distance of 120 feet from the shore and at Coquitlam only thirty feet of open cut was necessary.

Hand drilling was employed at each heading until January of 1903, when the installation of compressor and haulage plants at both portals was finally completed.

Owing to the uncertain nature of the work it was decided after an examination of the tenders on tunnel work to let the contract on a percentage basis, based on a sliding scale in which the contractor's profits are increased in proportion to the decrease in cost per foot from the tendered price and an independent bonus provided for speed.



ROLLER GATES CONTROLLING WATER FLOW INTO TUNNEL



DETAILS OF DAM CONSTRUCTION AND PLACEMENT

From an engineer's standpoint this form of contract is advantageous, since it places him in complete control of the work that ordinarily falls to the contractor.

The tunnel construction plants were furnished by the Vancouver Power Company and the following grades were adopted for drainage and haulage: From the Trout Lake portal the tunnel has a rising grade of 0.14 per cent for 6300 feet and thence a decline of 0.02 per cent for 5600 feet to the drainage sump, where the pumping plant was located. From thence a rising grade of 6 per cent for 875 feet to the Coquitlam portal.

A short line of thirty-six-inch-gauge railway was run from salt water to the Trout Lake tunnel portal, the first section of which is 1800 feet in length and has a rise of 400 feet. This portion is operated by a Lidgerwood hoist having a pull of 6000 lbs., while the balance of the road is level and is operated by an electric locomotive.

The tunnel plant at the Trout Lake portal consists of an eighty horsepower brick yard type boiler, an Armington and Simms high-speed engine, driving a sixty kilowatt direct current 500 volt generator, supplying current for lights, ventilating motors and electric haulage and a Leyner two-stage air compressor, having a capacity of 400 cubic feet of free air per minute. At the Coquitlam portal a duplicate plant was installed with slightly greater boiler capacity in anticipation of pumping as the work progressed. For the transportation and installation of the latter plant it was necessary to built two miles of new road through a dense forest and swamp and to rebuild seven miles of old road and bridges. Of the nine miles of road nearly four miles were corduroyed owing to the boggy nature of the ground.

The normal sectional area of the tunnel is seventy-three square feet, the section being nine by nine feet, with rounded corners. The method of procedure in attacking the face or heading was as follows: A tunnel bar five inches in diameter and nine feet in length was first set in position across the tunnel and about three feet below the roof, the miners standing on the muck of the previous blast. From this position of the bar, three back or upper holes, four breast holes and four cut holes were drilled. The uppers were dry holes and formed the roof. The breast holes were wet holes, i. e., having a slight dip below the horizontal, and the cut holes had a slope of about 30 degrees below the horizontal. While these holes were being drilled the muck from the previous blast was removed and the bar then lowered and four "lifters" drilled under the bar to take out the floor to grade. During the time the miners were drilling the "lifters," the muckers laid mucking plates of quarter-inch iron about four feet square on the floor of the tunnel for a distance of thirty feet back from the face, removed dull steel and cleaned up for the blast. The iron plates afforded a suitable floor for shoveling the broken rock after a blast and greatly facilitated the speed of mucking, which work was done by nine men working three eight-hour shifts, two men shoveling at a time and one resting. About sixty tons of rock were removed each twenty-four hours.

Beside the compressor, a receiver having a capacity of 100 cubic feet of air was provided at each portal, located just outside the tunnel. Four-inch standard pipe was used underground for a distance of half a mile from the receivers and three-inch pipe for the remaining distance, with about 200 feet of two-inch pipe as temporary connection between the three-inch pipe and drills. To overcome the trouble due to wet air short drops were placed

TEMPORARY CONTROLLING DAM

at one-half mile intervals in the air line and drip cocks on the pockets were left "cracked" to expel the condensed moisture when trapped. Flanged unions were provided at 500-foot intervals to facilitate repairs and all joints were made up with oil and graphite, the pipe threads being run over with a die before taking the pipe into the tunnel. With sufficient care in making the joints no leakage was apparent.

The work was started with four three and one-quarter-inch Little Giant rock drills at each heading, two being constantly in service and two in the repair shop or ready for use. These were used for nine months with an air pressure of 100 lbs. per square inch. As work progressed the rock became harder and larger drills, three and five-eights inches in diameter, and seven-inch stroke, of the same type and using 100 lbs. pressure, were installed. A number of different types of drills were tried on the work, some of which gave excellent results, but the Rand Slugger drill with piston valve proved preferable to the miners and these were finally adopted. Speed being an important factor in the work, the drills were worked to the utmost limit, and the cost of repairs has been comparatively high per foot advance. The policy of keeping machines in the best possible condition had been consistently followed and in December, 1904, new shells, cylinders and pistons were provided for each machine. Experience on the work has shown that the useful life of a machine drill under the conditions obtaining is at most twelve months and resembles the old maid's stockings which she wore for five years—repairs, five new feet and two new legs.

The shanks of the drills used were of one and three-eighths-inch Octagon, Crescent or Canton steel, fitted with one and one-eighth-inch bushings for the chucks. The bits were welded to the shanks and made of Cruciform steel, varying from one and one-quarter inch to two and and one quarter-inches in diameter and swedged out to from one and one-half inches to two and one-half-inch bits in one-quarter-inch variations. Drill sharpening was done by a blacksmith and helper at each heading with the use of special tools. Tempering was done by cold running water and also by dipping in a mixture of prussiate of potash and water, followed by a plunge in cold water. Good results were obtained by each process, and under ordinary conditions each steel will drill from eighteen to twenty-four inches with one sharpening.

On an average 120 drills were sharpened per day with the use of 100 lbs. of blacksmith coal.

Owing to the fact that cars of sufficient capacity capable of being dumped by one man could not be obtained, special cars were designed and built. These have a height of only thirty inches above the rail and a capacity of two cubic yards. The bodies are of steel and swing on a center king-bolt, dumping out of one end and on either side of the track. The cars weigh 1500 lbs. and are equipped with twelve-inch, standard pattern chilled wheels, pressed on to two and one-half-inch axles. The cost of the cars was $130.00 each.

A General Electric locomotive with double equipment, consisting of two ten horsepower, 500 volt motors, and series-parallel control, having a draw bar pull of 1200 pounds was provided for haulage at each heading. Each locomotive readily handled two loaded cars on a 6 per cent grade, developing thirty-two horse power for about a minute and a half. They were worked at a speed of from four to six miles per hour and proved eminently

EXCAVATION FOR CONCRETE DAM

satisfactory, costing very little for repairs. Two motor men working twelve-hour shifts handled the cars from the face of the tunnel, dumped them and loaded all sharp steel taken into the tunnel.

As the tunnel penetrated the mountain the question of ventilation had to be met, and a solution was reached by the installation of a twelve-inch galvanized iron pipe of number twenty-four gauge, at a cost of 7½ cents per

INCLINE TRAMWAY

pound. Forty-inch sturtevant fans, driven by five horse power motors were placed at 2000-foot intervals, working in series, each fan forcing the air to the next one in the line. The speed of the fans was between 1300 and 1400 revolutions per minute, and served to clear the tunnel of gas and smoke in forty-five minutes after a blast. At the same time compressed air was blown through a one-quarter-inch opening into the face and aided in forcing the gas back to the end of the twelve-inch ventilating pipe, which was kept about 100 feet away from the face, out of reach of flying rock and debris. As the ventilating pipe was subject to extremely heavy concussions, a very strong and rigid plan of holding it in place had to be adopted.

Several methods of lighting the tunnel were tried but all were abandoned in favor of candles, which, though expensive, were best suited to the miner's requirements. The plants and camp buildings were all electrically lighted.

The fuel item for camps and plants proved expensive, owing to the difficulty of landing the wood at point of use. At the Coquitlam portal logs were fallen into the lake from the shores and towed to the vicinity of the camps, where they were cut up into four-foot lengths while in the water and then hauled out on an incline by means of the electric locomotives and steel blocks with wire cab'e. The timber used was Douglas Fir, which ranged from two to eight feet in diameter and sawing was done with a drag saw driven by a five horsepower motor. At the Trout Lake heading the logs were hauled out with a donkey engine and hand sawn.

As already mentioned the working tunnel floor was begun at the Coquitlam portal at an elevation of five feet above high water level in the lake, for safety during construction. During the progress of the tunnel proper, a shaft was sunk in the floor of the working tunnel at a point thirty feet from the portal, to a depth of eighteen feet, the floor level of the finished tunnel. From the bottom of the shaft, a cross cut, or heading, was run at right angles to the tunnel for a distance of twenty feet on each side of the center line. The cross section of the heading is ten feet by ten feet and from it three eight-foot by eight-foot openings, parallel to the tunnel were driven into the lake, forming a submerged intake. From the center of the cross heading and directly under the upper working tunnel, the finished tunnel was driven on a 1 per cent grade to meet the former, which has a grade of 6 per cent to the portal. While this necessitated the driving of some 300 feet of extra tunnel, it insured freedom from lake water and interruption to the work. During construction, and until the tunnel headings met, about ten feet of rock was left in place in each of the three intake tunnels to guard against flooding.

For control of the flow of water through the tunnel two gates are provided in the main tunnel at a distance of sixty feet from the Coquitlam portal. The upper, or working tunnel, has been converted into a gallery from which the gates are operated by means of screw stems, ball bearing nuts and hand wheels, resting on a framework fastened rigidly to the rock by anchor bolts, while all the spaces between frame and rock are filled with concrete for water tightness. The gates are each four and one-half feet by nine feet, built up of structural steel and carrying on each side brass rollers, running on "I" beams, which form the framework. The gates carry flanges on each side, which seat only when the gates are closed.

The formation of the mountain mass pierced by the tunnel consists essentially of syenite or quartz syenite, a granitoid rock, consisting of quartz, feldspar and horn-

DAM AND HEAD GATES

blende, with occasional dykes of dioryte. The rock increased in hardness from the surface and the dioryte was found invariably hard and tough. The structure was very uniform and hard, no timbering being required on the entire length of the tunnel.

Temperature readings were taken at each 1000 feet advance and showed a rise of only two degrees for each

STEEL PRESSURE PIPES

reading. The maximum temperature of sixty degrees F. was reached at a distance of 3500 feet below the surface and 6000 feet from the portal.

The dam at the outlet of Coquitlam Lake is a rock-filled, timber crib structure.

The cribwork is made of twelve inch by twelve inch sawn timbers, placed six to seven feet apart, center to center, and drift bolted together with three-quarter inch drift bolts. The apron consists of twelve inch by twelve inch by thirty-eight foot timbers driftbolted to twelve inch by twelve inch sills and also drift bolted to one another laterally. Below the main apron there are two smaller ones, one on each side of the river, which protect the abutments and prevent any undermining from the action of the water.

The river bottom on which the foundation rests consists of a pavement of large boulders, underlying which is glacial hard pan.

Along the upstream toe of the dam these boulders were removed and a trench dug into the hard pan, a double row of sheet piles was then driven along this trench and spiked to the twelve by twelve timbers, the trench being refilled with the best available material, well rammed. The top sheeting consists of a double thickness of planking, the bottom planks being four inches and the top ones two inches in thickness. The length of the dam is 113 feet and its height is fourteen feet. The top width is twelve feet and the width at the base fifty feet, not including the apron.

The reasons for the unusually extensive apron to this structure will be better understood when it is known that at flood water large fir and cedar drift logs six to eight feet in diameter pass over the dam.

The dam was built by day labor, except the sawing of the timber. This was all cut near the dam site at a cost of $15 per thousand board measure, and chiefly consists of hemlock.

A portable sawmill was erected at a point about 700 feet upstream from the dam, and the sawn timber was dumped into the stream and floated down to the work, where it was picked out of the water by derricks (one on each side of the river), put into place by only one handling and immediately drift bolted.

The derricks were operated by a donkey engine and were used also in placing the rock filling in the cribs.

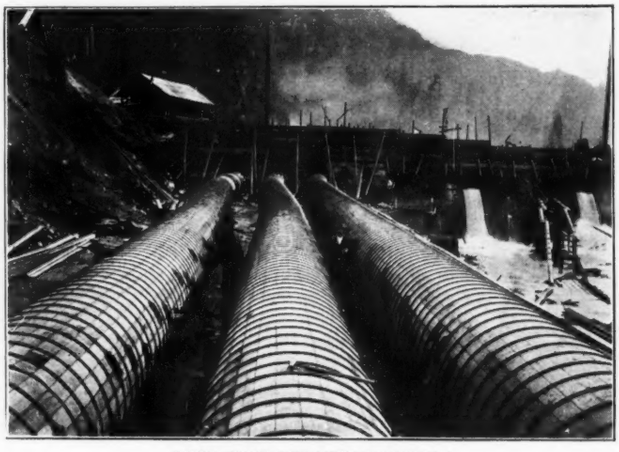
The total amount of timber used in the structure was 600,000 feet board measure, and the cost, including the intake crib and head gates for the City of New Westminister water pipe was $25,000.00.

As there was not sufficient rock to be had in the immediate vicinity of the dam to complete the filling, a quantity was brought from a point upstream, where a quarry was opened and a short tramway built to haul the rock to the dam.

The work was only partly finished the first season, as its completion would have flooded the tunnel. The abutments, foundation timbers and aprons were put in and covered over with temporary planking. This planking was removed and the rest of the work completed after the tunnel was finished.

The dam across the outlet of Trout Lake was built by day labor and is located at a point where the creek passes through a deep ravine about half a mile from the lower end of the lake.

Before deciding upon the location, a large amount of preliminary work had to be done in order to ascertain



WOOD STAVE PIPE LINES BELOW DAM

the nature and exact position of the underlying bedrock, which was covered over with a thick variable strata of hard pan. This hard pan had to be drilled and blasted, and owing to the numerous large boulders it contained, was difficult material to handle.

Ten shafts were sunk through the hard pan, varying from twenty feet to fifty-four feet in depth, and connected by drifts running along the bedrock.

WOOD STAVE PIPE LINES FROM TOP OF DAM

When the final location was decided upon, the site, which was covered with a dense growth of large fir and cedar timber, was cleared and a temporary dam built at a point of about 100 feet upstream. This dam was a long crib structure with a rock filling, about twenty feet in height and cost $1.00 per cubic yard of contents. It was necessary to give it sufficient stability to withstand flood water, which at one time passed over its entire crest.

A flume was built from this dam and extended down along the creek bed for about 600 feet, past the site selected for the permanent dam.

In order to make the excavation for the permanent dam, a donkey engine and large boom derrick were installed on each side of the creek, and as the material was excavated it was dumped into the flume by means of the skips and sluiced away. All large boulders met with were picked up and placed to one side and afterwards used in the concrete filling.

In this way 20,000 cubic yards of material was removed, most of which passed through the flume, being handled only once.

This ground was of such an exceptionally hard nature that no impression could be made upon it with picks, so that it had to be drilled and blasted. Some of the boulders met with were very large, containing as much as five cubic yards, and at first were mistaken for bedrock.

After the excavation was completed the surface of the rock was washed clean and carefully examined for the entire length of the dam and all loose pieces and partially decomposed rock removed. It was found to be granite of a good sound nature and most favorable for the foundation of a dam.

The bedrock, after being thus prepared, was drilled with small holes six inches deep, and three feet apart, which were loaded and fired, producing a rough surface, such that a good bond would be made with the concrete.

In building the base of the dam no forms were used, but the entire width of the excavation was filled in with concrete, and brought up to a level surface, after which the form timbers were put in place.

The concrete consisted of one part Portland cement, two and one-half parts sand, and five and one-half parts crushed granite.

Along the upstream face of the dam a little different mixture was used for a thickness of about eighteen inches. This contained more cement, the object being to secure water-tightness.

The concrete was mixed with a gravity mixer, which emptied into a skip. It was then removed with a derrick and placed in the work. The mixer was hung on rollers and did duty for skips, which it filled alternately.

The concrete was placed in the dam in layers about ten inches in thickness, and so built up that frequent jogs or offsets were left to make a thorough bond with the following course.

Before commencing a new course, the top of the foregoing one was roughened with picks and then washed off clean with a hose. The concrete was then put into place and trimmed with shovels and well tamped.

It was found that the best results were obtained when the concrete was made rather wet, this was especially the case when boulders were placed into the work. The concrete work was carried on day and night, and was completed within five months of its commencement. Were it not for the fact that it was impossible to get sand delivered to the work in sufficient quantities to keep the entire force of men employed, this work could have been completed in a much shorter time.

In one ten-hour day shift 105 cubic yards were placed, and in one nine-hour night shift 87 cubic yards, making a total of 192 cubic yards of concrete work in one day.

The sand used came from the sea bottom near the mouth of the Fraser River, where it was pumped on to

PIPE LINES FROM TOP OF POWER HOUSE

scows and then towed to the landing, where it was loaded into cars, hoisted up the hill by means of a steam hoist and delivered to the dam, where its cost amounted to about $1.00 per cubic yard. This sand, although not coarse, was very clean and sharp and produced first-class concrete.

The rock used in the work was quarried out of the hillside at a point about 300 feet from the work. It was loaded into cars and landed at the crusher by means of a small gravity tramway. The top of the dam was built up to the level of Trout Lake. It has a length of 361 feet and a maximum height of fifty-four feet. It has a width of thirty-five feet at its base, and a top width of seven feet, and contains 10,000 cubic yards of concrete.

There are ten fifty-four-inch steel pipes and two twenty-four-inch pipes penetrating the dam at a point twenty-two feet below its top. These pipes are all fitted with special roller gate valves at the face of the dam, with separate screens for each pipe.

Four different brands of Portland cement were used in the work, viz., White Bros., Hercules, Condor, and Alsen.

These cements were all tested as the work progressed, each shipment being sampled.

There were 12,400 barrels of cement used in the dam at a cost of about $3.50 per barrel delivered at the work.

The excavation cost $1.00 per cubic yard and the concrete work $8.50 per cubic yard.

The cost of the work was made considerably greater than it otherwise would have been on account of the high rate of wages for common labor which prevailed, and the poor class of labor available. The night work also added to its cost. The sand had to be pumped from the sea bottom and in rough weather it was impossible to get it delivered fast enough to keep the force employed.

The intake gate valves are placed in guides bolted to the face of the dam and are fitted with brass rollers, on which the thrust due to the water pressure comes. A circular ridge on the back of the gate is machined to make the seat and a corresponding seat is made on the gate frame, to which the pipes are riveted. These seats are not quite parallel to the plane of the rollers, so that when the gate is lowered to a certain point it takes its seat and the pressure on the rollers is relieved, but immediately the gate is raised a fraction of an inch the pressure comes on the rollers again. The gear for operating the gate is a simple screw stem and hand wheel, with roller bearing which takes the pull. The gates are quite tight and can be operated with ease by one man at all stages of the water.

There are sixty acres of land lying between the dam and the lower end of Trout Lake, which have been flooded, and a central canal about fifty feet wide and twenty feet deep was excavated, connecting the new lake with Trout Lake. This gives a reserve or storage of water of about sixteen feet in depth over an area of 500 acres, which can be utilized when required, and forms a balancing reservoir.

This enables the attainment of very high peak loads and reduces the waste of water to a minimum, for immediately the water is shut off at the power house it commences to store in this resorvoir instead of running to waste.

The pipe lines extend from the dam to the power house at sea level, for a total length of 1800 feet, and are built to curves and tangents both vertically and horizontally, no angles being allowed.

The pipe line was graded and the pipes laid in the trench ready for riveting by day labor. The pipes were made and riveted together on the ground by the Vancouver Engineering Works, Ltd., of Vancouver, B. C.

The first trench excavated was made to accommodate five pipes, it passed over a vertical rock bluff seventy feet in height, which had to be cut down, and at the lower end in order to extend the pipes into the Power House it was necessary to put two short tunnels through the rock, 110 and 135 feet in length, respectively. These tunnels were built in curves with 200 feet radii.

On one portion of the pipe line, where a creek is crossed at the foot of the bluff, it was necessary to lay the pipes on temporary trestle, which were constructed to suit the vertical curves taking place at these points. The trestles afterwards were used as false work, when they were finally replaced by concrete piers.

A tramway was built in the pipe trench for its whole length and operated by a steam hoist. In this way all the pipes were put in place, the track being shifted over laterally as each line of pipe was placed.

The average depth of the trench excavated was six feet, and the bottom was brought to an even surface. This enabled a track being laid along it, and greatly facilitated the handling of the pipes, and the building of the lines.

The material excavated was afterwards used to cover the pipes, all the rock being hand placed under the pipes, and the whole work covered up with the finer material and sown over with clover seed.

Where curves occur at the lower end of the pipe line, the pipes are kept in place by concrete piers set from twelve to sixteen feet apart.

The upper portion of each pipe line is of wooden stave construction, fifty-four inches in diameter, and extends from the dam for a distance of 800 feet to a point where it is under pressure due to seventy-five feet head. From this point to the power station the pipe lines are of riveted steel, varying in thickness from nine-thirty-seconds inch to seventeen thirty-seconds inch and ranging in diameter from forty-eight inches to forty-two inches at the lower end.

At the present time three main pipe lines and one exciter pipe line are installed, the total length of each of the steel lines being 1000 feet. Each line is fitted with air valves at three different points, a relief valve at the lower end and a stand pipe just below the dam.

The exciter pipe line is constructed of steel throughout its entire length and is twenty-four inches at the upper end and eighteen inches at the lower end. The thickness of plate varies from one-eighth to one-quarter inch.

The wooden stave pipes were built by the Excelsior Wooden Pipe Co., of San Francisco, and cost approximately $4.00 per lineal foot, the lumber being delivered at a cost of $37.50 per thousand feet board measure.

The cost of the steel lines was approximately $14.50 per lineal foot for the large pipes exclusive of excavation for the trench, which is 1800 feet in length and about thirty-eight feet in width. This work includes about 400 feet of trestle and 250 feet of tunnel, also about 3500 cubic yards of rock work in cutting down a bluff about seventy feet in height. The balance of the excavation was made through large boulders, gravel and hard pan, all of which was overtopped with a dense growth of immense cedar and fir trees.

The cost of the pipe line grading including the hand placing of broken rock around the pipes, back filling, concrete piers and anchorage amounted to about $25,400.00.

(Continuation in next issue.)

The Jhelum River Power Plant.

THE Government of British India has for some time pursued a broad-minded policy in developing the latent possibilities of the immense and valuable country over which it exercises sovereignty and its officials have interested themselves in providing for the future welfare and enlightenment of the native inhabitants. Among other laudable projects, which the Government has instituted, has been the commissioning of some of the most capable British Army engineers to plan for and construct public works, such as would aid in the general advancement of the native industries and the development of the commerce of the country.

The first notable project undertaken for the generation and distribution of electricity was that of the Cauvery Power Scheme, located in the Province of Mysore in Southern India. Work on this plant was started in 1900, the initial installation being completed after many difficulties in June, 1902. About a year ago, the second installation or extension of this plant, consisting of 3610 kilowatts generator capacity, was completed. This increased the possible output of the entire plant to 7920 kilowatts, making it the largest hydro-electric installation now operating in Southern Asia, if not in the entire continent.

The Cauvery River Falls are located near the site of

FIGURE 1. JHELUM RIVER POWER PLANT. POINT OF DIVERSION FROM JHELUM RIVER AT BANIER

FIGURE 2. JHELUM RIVER POWER PLANT. FLUME LINE JUST BELOW THE HEADWORKS

the old Hindu village of Sivasamudram. The Cauvery River at this point is the dividing line between the Mysore Province and the Madras Presidency. The falls furnish a head of nearly 400 feet, giving an average calculated horsepower of approximately 12,000 during the dry season of the year, and a maximum of over 200,000 horsepower at times during the monsoon or rainy season. Power is transmitted at a pressure of 35,000 volts over two three-phase transmission lines, a distance of ninety-two miles to the Kolar gold fields, where it is utilized almost entirely in mining operations. The entire success of the original scheme is thoroughly emphasized by the the recent doubling of the output in order to meet the demands of the Kolar gold mining companies for the cheap power thus afforded. Arrangements are now being made, whereby the City of Bangalore, of 180,000 inhabitants, is to be supplied with light and power over a separate sixty-mile 35,000-volt transmission line. It is also probable that, during the present year, the City of Mysore, the seat of the Government of Mysore State, will be supplied with light and power over a separate forty-mile transmission line.

The chief credit for the completion of the Cauvery Power Plant is due to Major A. J. de Lotbiniere, R. E., deputy chief engineer of the Government of Mysore, who not only conceived the plan of the installation, but successfully arranged for the financing of the entire project, overcoming prejudices that would have deterred a man less sound in his convictions. He afterwards arranged for the purchase of the entire electrical and hydraulic equipment and supervised its installation.

The first power scheme to be undertaken after the Cauvery is the Jhelum power installation on the Jhelum River, in Kashmir. The power plant is to be installed near Rampur about fifty miles below Srinager, where a six-mile conduit will give a head of water at the plant of about 400 feet. It is calculated that with the minimum flow in the Jhelum, it will be quite possible to obtain 100,000 horsepower at this point, thus making a very valuable asset for Kashmir State and a plant far larger than anything that the Mysore Government can obtain from the Cauvery. The present plants call for an installation of about 20,000 horsepower. It is planned to use the power for operating the Kashmir section of the Jhelum Valley Railway electrically along its entire length of 180 miles. A single-phase system of traction will undoubtedly be installed. Possibly the most important immediate use to which the power will be put will be in operating dredgers for the purpose of deepening the Jhelum River in the Kashmir Valley, and thus minimizing the floods, which, under existing circumstances, periodically devastate the entire country. The contemplated plant will also allow of the reclamation of a very large tract of land, and permit of the storage of water in Wular Lake above the power plant for sale to the Punjab Irrigation Department. Another important use of the power will be for operating the large silk factory at Srinager, and also for supplying with current the electrical water heaters in the silk mill. In addition, the power will be utilized for other industrial purposes and for lighting in Srinager and in Abbottabad, Murree and Rawalpindi, prosperous towns in the British Province of Hazara, lying to the west of Kashmir.

Kashmir is the beautiful elevated and enclosed valley in the Himalaya Mountains of which Mohammedan writers have painted such rapturous pictures, and from which Moore has drawn material for some of his famous writings. It is a country "where spring encircles a fresh, green, smiling valley with a noble belt of glistening snow-capped ridges, and where autumn fills the eye

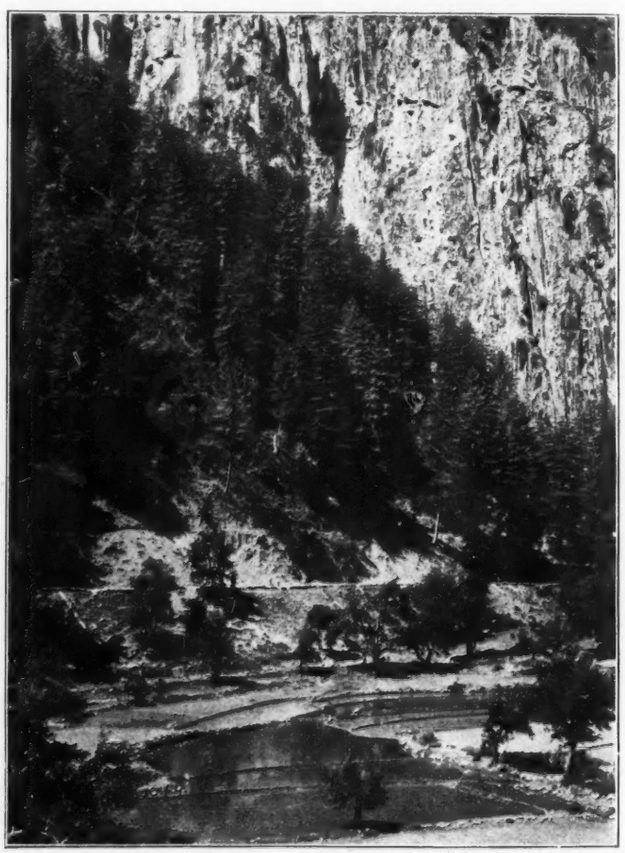


FIGURE 3. JHELUM RIVER POWER PLANT. FLUME LINE ABOVE CART ROAD NEAR RAMPUR

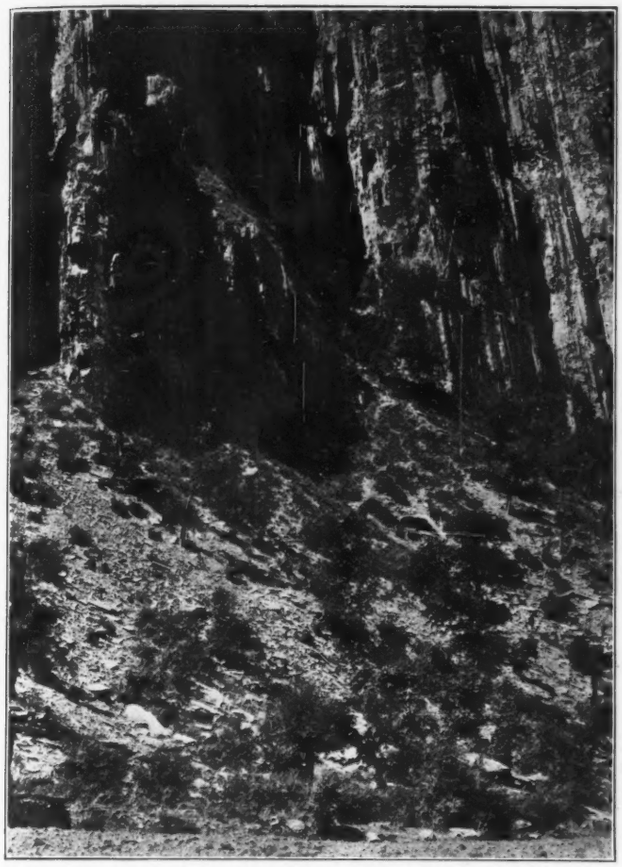


FIGURE 4. JHELUM RIVER POWER PLANT. FLUME LINE AT FOOT OF CLIFF

with the wonderful richness of vari-colored foliage." The valley lies north of the Punjab, in the northernmost part of British India. It is surrounded by lofty hills with one opening on the west, and the Jhelum River, after wending its way across the plateau, discharges through this opening to the west and south.

The Kashmir Valley is but a small portion, in area, of the State of Jammu and Kashmir, which extends north to the southern boundary of East Turkestan, and east to the Plateau of Tibet and the Dominion of the Chinese Empire, and is bounded on the south by the Punjab and on the west by the British District of Hazara. The State has an area of 80,000 square miles, and is mountainous throughout nearly its entire extent.

And when we speak of mountains we must realize that we have here the largest and noblest specimens that our globe affords. Spreading over the northern part of India in a great semi-circle, 1500 miles long, the Himalayas present every phase of grandeur known. The extraordinary scale on which every part of the mountains is developed, the actual vast dimensions of the main features, the apparently endless succession of range after range, of ascent and descent, of valley and mountain top, of river, torrent, and brook, of precipitous rock and grassy slope, of forest and cultivated land, all produce impressions of wonder, which cannot be equalled nor exceeded on any other chain. "Upon these mountains alone, of all on the earth, can the traveller, as he climbs their slopes, obtain at a glance a range of vision extending five miles in vertical height, from 2000 or 3000 feet to 29,000 feet above the sea, and see spread out before him a compendium of the entire vegetation of the globe from the tropics to the poles. Here may the eye, as it sweeps along the horizon, embrace a line of snow-clad mountains, such as exist in no other part of the world, stretching over one-third of the entire circle, at a distance of forty or fifty miles, their peaks towering over a sea of intervening ranges piled one behind another, whose extent on either hand is lost in the remote distance, and of which the nearest rises from a gulf far down beneath the spectator's feet, where may be seen the silver line that marks a river's course, or crimson fields of amaranth and the dwellings of man. Sole representative of animal life, some great eagle floats high overhead in the pure dark blue sky, or, unused to man, fearlessly sweeps down within a few yards to gaze at the stranger who intrudes among these solitudes of nature."

An idea of the enormous extent of the Himalaya Mountains may be gained from a realization of the meaning of the statement, which is in no ways exaggerated, that along the entire range of the Himalaya valleys are to be found among the higher mountains into which the whole Alps or Sierra Nevada Mountains might be cast without producing any result that would be discernible at a distance of ten or fifteen miles. The land sloping up from the rivers varies in elevation from 2000 or 3000 feet above the sea to some of the highest peaks in the Himalaya range. The average elevation of the crest of the watershed exceeds 18,000 feet, and the valleys which traverse the mountains between the plains and the great watersheds are for the most part little more than gigantic ravines, at the bottoms of which flow the rivers, in contracted beds, which, at variable intervals, open out into narrow alluvial flats capable of cultivation. The level of the river-beds is necessarily characterized by great variations. Valleys only 2000 or 3000 feet above the sea open up into the very heart of the mountains and carry with them the heat and vegetation of the tropics among ranges or summits which are capped with eternal snow.

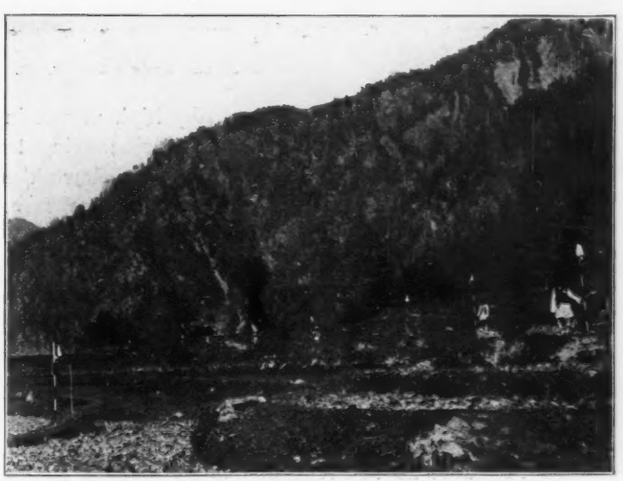


FIGURE 5. JHELUM RIVER POWER PLANT. LOWER END OF FLUME AND SITE OF FOREBAY

Within ten miles of the line of the great peaks the rivers, as a rule, are flowing at an elevation of little more than 4000 or 5000 feet; but, from that point on, the acclivity suddenly and rapidly increases and the river-beds, in a very few miles, are found to be at an altitude of 9,000 or 10,000 feet, indicating a general elevation of the whole surface. The rivers vary greatly in volume in different seasons of the year, depending upon the more or less rapid melting of the snow and the varying temperature of the day, or the power of the sun.

over a slight depression in the plain, and forms the Wular lake and marsh. This lake is one of the very few which occur in the Himalaya. Leaving Wular Lake, the river pursues its course southwesterly about eighteen miles to the gorge at Baramula. From this point on the stream is more rapid through the narrow valley which conducts it westward seventy-five miles, where it turns sharply to the south, and, after a run of about 200 miles, discharges into the broad valley of the Punjab on its way to join the great Indus river, the Nile of Western

FIGURE 6. JHELUM RIVER POWER PLANT. FLUME LINE PASSING THROUGH A RICE FIELD

The Valley of Kashmir is enclosed by high mountain ranges, the highest peak being Nanga Parbat, lying to the north. This mountain rises 26,629 feet above the sea and has an extensive glacier on its eastern face. Spurs from this mountain averaging over 18,000 feet in height bound the northern watershed of the upper drainage basin of the Jhelum river. On the east is the Western Himalaya Range and on the south of the valley lie the Panjal Mountains. The lowest part of the valley is a mile above the sea and its mean height 6000 feet.

The River Jhelum flows northwest through the middle of the Kashmir valley. After a slow and winding course, it expands about twenty-five miles below Srinager

India. It is in this gorge, about fifty miles below Srinager, where the Jhelum water-power plant is being built.

The Valley of Kashmir, sheltered from the southwest monsoon by the Panjal range, has not the periodical rains of India. Its rainfall is irregular, greatest in the spring months. Occasionally heavy storms in the monsoon pass over the crest of the Panjal and produce a heavy rainfall on the elevated plateaus on the Kashmir side. Again clouds pass over the valley and are arrested by the higher hills on the northeast side, on which they pour themselves. Snow falls on the surrounding hills at intervals from October to March, and sometimes in

FIGURE 7. JHELUM RIVER POWER PLANT. FACE OF THE BLUFF BACK OF THE POWER HOUSE DOWN WHICH THE PRESSURE PIPES WILL BE CARRIED

great quantity. In the valley, the first snow generally falls the first of December, but never to any great amount.

Kashmir has for years been noted in the commercial world for its fine grade of shawls, both loom-made and hand-sewn. Since the recent depression in the shawl trade, silk manufactures have been developed to a large extent and other cloth industries have also been encouraged. The natives are also skilled in metal work and other handcraft.

The admission of visitors to Kashmir each season is limited, the country thus maintaining a custom, which more than eight centuries ago was in vogue, the mountain passes being watched and few outsiders admitted.

The Government of Jammu and Kashmir State is independent, the powers being invested in the Maharajah and a native council. Dealings with other states are subject to the supreme authority of the Government of India. The annual tribute of the Maharajah, presented in token of the supremacy of the British Government, is "one horse, twelve perfect shawl goats of approved breed (six male and six female) and three pairs of Kashmir shawls." The Maharajah, when in British territory, receives a salute of nineteen guns. The present Maharajah is Pertab Sing.

After successfully completing the preliminary arrangement for carrying on the important work, connected with the Jhelum power installation, Major de Lotbiniere was instructed last May by the Jammu and Kashmir State Council, acting for the Maharajah of Jammu and Kashmir, to proceed to Europe and America in order to interview the leading hydraulic and electrical manufacturers and to ask those selected to bid upon the machinery and materials for the plant. Carrying out these instructions, he visited the works of those leading manufacturers on both continents who were considered for the work and personally inspected their manufacturing establishments, as well as power plants in which their machinery was operating.

As a result of this careful investigation, Major de Lotbiniere, who had full powers for the acceptance of the tenders submitted, has recommended to his Government that the contracts for the entire hydraulic and electrical equipment be awarded to firms in the United States. The contract for electrical equipment goes to the General Electric Company of Schenectady, N. Y., and that for the hydraulic plant to the Abner Doble Company of San Francisco. The latter contract calls for the hydraulic plant complete from the forebay to the tailrace, including the intake, valves, pressure pipes, pressure-pipe thrust blocks, interior piping, water wheels and nozzles, hydraulic governors, and all details necessary for the hydraulic equipment. The apparatus and materials are to be delivered at the Port of Karachi, India.

That this contract should come to a San Francisco firm not only reflects great credit upon the State of California, but upon our entire Pacific Coast. It is significant of the increasingly important position which our manufacturing establishments and our mercantile houses on the coast are taking in the furnishing of materials and supplies for, and in the material development of, the countries in the Far East. That the British engineering

FIGURE 8. JHELUM RIVER POWER PLANT. SITE OF POWER STATION

representatives of the Indian Government, with the machinery markets of the entire world to choose from, many of them established before San Francisco was founded, should select a California firm to design and construct its hydraulic equipment certainly speaks volumes for the high character of the work done by the successful tenderer. It is also a just recognition of the notable pioneer accomplishments in hydro-electric engineering, which are evidenced so forcibly by the water-power plants that dot our mountain slopes throughout the entire western portion of the country, converting the abundant energy of our rivers and lakes into electricity for the varied uses of mankind.

Water for the power plant will be taken from the Jhelum at Banier, where a masonry diverting dam will lead the water into the gravity conduit. Figure 1 is an illustration of the Jhelum at the headworks or point of diversion and shows the river in one of its characteristic stages. A party of British engineers and natives may be noted in the foreground. This illustration, as well as the others that follow, depict in an excellent manner the extremely interesting and magnificent country which is the scene of this notable power plant.

The gravity conduit line will be approximately 34,000 feet in length and for the upper 8500 feet will consist of an excavated ditch lined with masonry, the bed width of the channel being ten feet six inches. Figure 2 is a view of the ditch line just below the headworks, showing the river and preliminary construction work started on the ditch. This illustration shows a group of natives in their characteristic dress.

The remaining portion of the water channel will consist of a rectangular flume, or a wooden stave pipe such as has been installed so successfully in connection with plants of this character on the Pacific Coast. If a flume is constructed it will probably have a width of eight feet and a height of eight feet six inches, with a water-carrying section for the full capacity eight feet deep. The flume will have a grade of between five and six feet per mile, and will be constructed so as to give a velocity of about nine feet per second. Its capacity will be over 500 cubic feet per second.

From the lower end of the masonry-lined channel the flume or pipe follows a contour aroung the steep hillsides until it reaches the plateau above the power house on which the forebay and settling chambers are to be located. There will be six short tunnels on the line varying in length from 100 to 700 feet and five trestles averaging 100 feet in length.

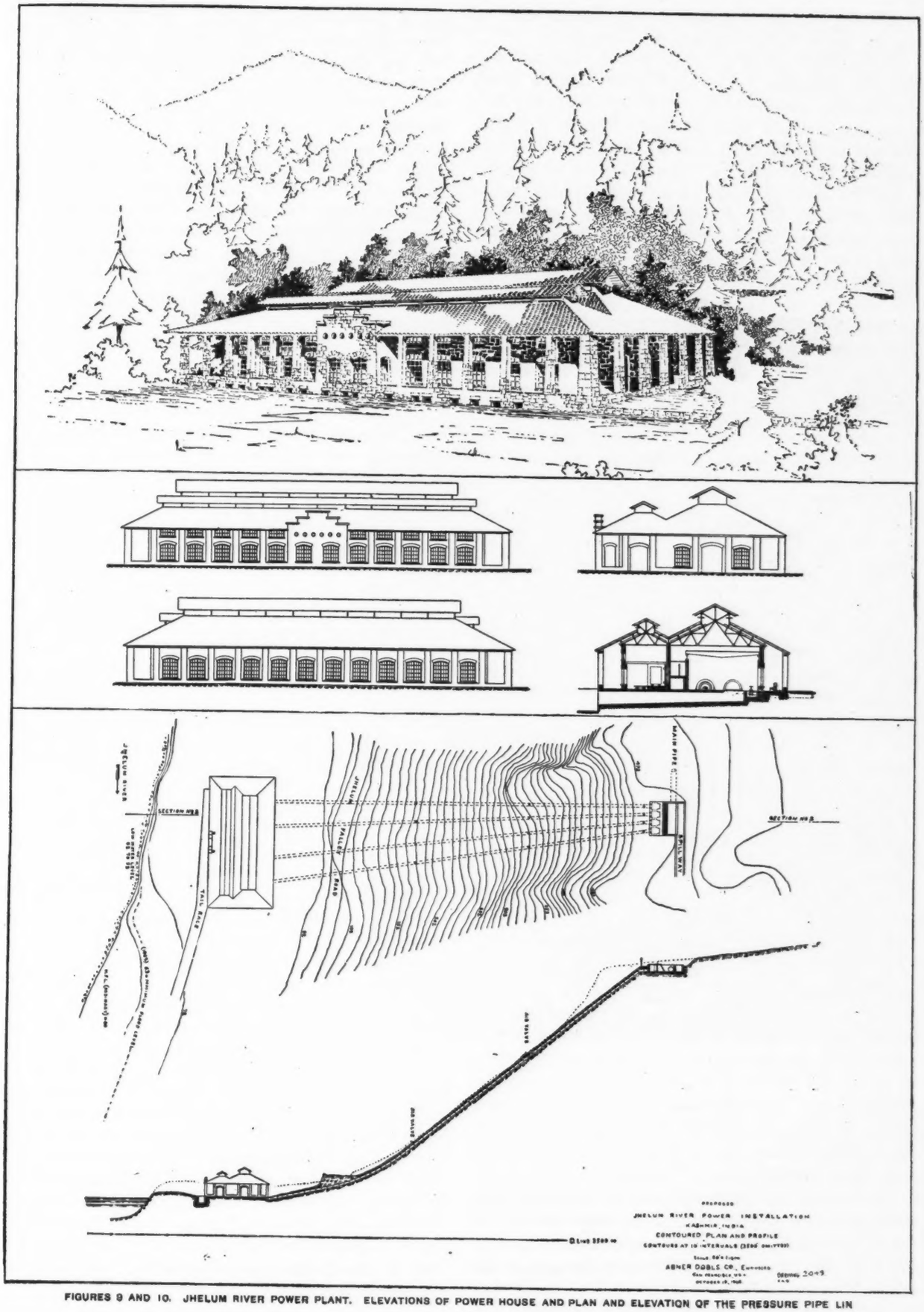
Figure 3 is a view on the flume line near Rampur and shows a bullock cart road, with the surveying stakes marking the line of the flume above. This picture illustrates the characteristic verdure of the canyon. Figure 4, a view of the flume line at the foot of a cliff, is typical of the country and illustrates the massiveness of the rock walls of the canyon. The scenes, Figures 5 and 6, show rice fields through which the flume will be carried. The formation of the hillside is very loose, the soil consisting chiefly of boulders embedded with clay. The flume for the most part will be built on a ledge cut in the hillside and in places where the soil is very unstable it will be supported on short posts or trestling. In case a flume is constructed, it will be roofed throughout with three-inch planking and covered with earth to serve as a cushion or protection against stray boulders which would thus jump over the flume and do little or no damage. A similar protection will undoubtedly be provided in case a wooden stave pipe is constructed.

In that section of the country there is plenty of snow during the winter, lasting usually from late December until April, and the avalanches that come down some of the nullahs (ravines or gorges) are at times very formidable. During the rainy season, too, which occurs during the summer months, the vast quantity of heavy rocks or driftwood that are carried down these gorges after a continuous rainfall, form a source of great danger to bridges and other construction works. For this reason the engineers of the Jhelum plant are planning to construct the gravity conduit underneath the beds of the ravines wherever possible, in order to allow everything to slide over without doing damage. Where a large ravine has to be bridged, central piers will be avoided, the flume being carried across on a single span, so as to allow all of the headway possible for the stream and the debris which it may carry.

For the construction of the flume or pipe line, a native wood known as deodar will be used. This timber, which is indigenous to the mountains of Northwest Himalaya, is nearly allied to the Atlantic cedar and the cedar of Lebanon. It is a large coniferous tree and the wood is extensively used on account of its extreme durability. About 5000 natives are now at work, cutting the lumber that will be needed for the construction of the flume. It is cut by hand and worked up by whip-saw into timbers four by nine inches in size. It is then carried on the backs of natives to the points where it will be used. Excellent carpenters and joiners are available, so the engineers anticipate no difficulty in obtaining good workmanship for the construction of the flume.

The forebay at the lower end of the gravity line and at the head of the pressure pipes will be constructed of masonry and will be provided with special headgates. It will be located on the plateau shown in Figure 5. The sliding elements of the intake gates will be of timber, all iron and metal parts necessary for the construction of the gates being furnished by the contractor. The intake and necessary grizzlys, valves, etc., for the headworks have been ordered for the entire ultimate capacity of the power plant.

The pressure lines carrying the water from the forebay to the power house will be carried down the hill shown in Figure 7, this view being from the cart road. The lines will consist of twelve riveted steel pipes designed with a factor of safety of five. Each pipe will supply one of the twelve hydro-electric units. For each pipe line a stand-pipe and two special vacuum valves will



FIGURES 9 AND 10. JHELUM RIVER POWER PLANT. ELEVATIONS OF POWER HOUSE AND PLAN AND ELEVATION OF THE PRESSURE PIPE LIN

be provided in order to protect the pipe against injury in case the water should be drawn out suddenly.

At the lower end of each pipe line the last length of pipe will terminate in a flange which will be bolted to a massive cast-iron thrust block which will rest on a heavy cast-iron sole plate or base. The latter will be mounted on a substantial masonry foundation and held in position by anchor bolts. This fitting will be designed to take the entire hydraulic thrust of the pipe, an ample factor of safety being allowed so that under the most severe conditions there will be no strain on the branch piping in the interior of the power house. Each pressure line will consist of a riveted steel pipe varying in diameter from thirty to thirty-six inches and a fifty-four to thirty-six inch taper pipe, ten feet long, at the upper end. The pipes will be 790 feet in length and will deliver the water under an effective head of 400 feet. Figure 10 shows in plan and elevation the proposed arrangement for the pipe lines and power house.

The interior piping of the power house will consist of welded pipe with welded flanges, all piping and fittings beyond the thrust block being designed with a factor of safety of ten and subjected to a test pressure of one and one-half times the working pressure for a period of five hours.

Twelve main units and three exciter units have been planned for the equipment of the power house. Each main unit will consist of a tangential water wheel with automatic oil-pressure governor delivering 1765 brake horsepower to the shaft, under an effective head of 400 feet. Each wheel will be direct connected to a 1000-kilowatt alternator, the speed of the unit being 500 revolutions per minute. The exciter units will each consist of a tangential water wheel delivering 285 brake horsepower to the shaft under an effective head of 400 feet. The speed of the exciters will also be 500 revolutions per minute.

All the hydro-electric units will be of the two-bearing type, the wheel runner being fastened on the end of the shaft. For each of the main units the hydraulic contractor will furnish a high-carbon, open-hearth steel forged shaft and two bearings of a special ring-oiling type provided with revolvable bearing shells. The exciter water-wheel runners will be mounted on the extended end of the exciter generator shafts.

The water wheels will be equipped with ellipsoidal buckets, needle regulating nozzles and centrifugal water guards. The regulation of the main units will be effected by means of hydraulic governors operating jet deflectors. For the exciter units hand regulation will be provided by means of the needle nozzles. The gate valves for each wheel will be of special construction with outside screw and yoke, bronze-mounted, with by-pass.

The electrical contract covers all the electrical equipment, including alternators, exciters, high and low-tension switchboards, step-up transformers and the wire and insulators for the transmission lines to Srinager, Abbottabad, Murree and Rawalpindi.

The power house will be of masonry construction and of the general design shown in Figure 9. It will have a double steel roof and will be served by a traveling crane, running the entire length of the building. The step-up transformers will be located in a bay of the main building or in a separate structure adjoining. A wide veranda, as noted in the elevations, will be a prominent feature of the power house, its purpose being to protect the employes from the fierce tropical sun. Separate masonry cottages will be erected for the station superintendent and attendants. The power house will be built on the bank of the Jhelum, with the floor about seven feet above flood level of the river. The site selected is a very picturesque one, and with a solid granite construction with red-tiled roof projecting over a wide veranda, the station will undoubtedly make a beautiful setting in a valley already enhanced by nature.

The conditions under which the plant will be installed are decidedly out of the ordinary as compared with similar work in this country. The specifications for the electrical and hydraulic equipment stipulated that no single piece of machinery should weigh more than four tons when packed, for the reason that there is 200 miles of road transportation, including a lift over a range of mountains 8000 feet high. Transportation in that section of the country is limited to bullock cart, and no single piece of machinery heavier than four tons can be transported, a total of five tons including the trollie (cart) being the maximum weight that can be hauled over the mountains.

Portland cement costs $7.50 per barrel delivered at the site, making its use prohibitive for heavy concrete construction. However, there is plenty of natural rock in the vicinity, so masonry construction will be used for the walls of the power house and for the foundations of machines, intake, forebay, etc. As deodar timber is plentiful and comparatively inexpensive, delivered at the site, it will be used wherever deemed permissible from an engineering standpoint, such as in the construction of forebay gates, flume or stave pipe line for the gravity conduit, trestling, etc. In case a wooden stave pipe is installed an entire plant for the manufacture of the staves will be shipped to the power plant site.

Native coolies will be furnished by the Government for the work, they making fairly efficient workmen when carefully directed. The pay of native laborers is naturally low, power station attendants getting but 15 rupees ($5) a month, and furnishing their own board.

The entire hydro-electric installation will be constructed, erected, tested and placed in operation under the supervision of Major A. J. de Lotbiniere, R. E., Major D. Fraser, R. E., and Captain Thomson, R. E., will act as his engineering representatives in London. A. C. Jewett, formerly of the General Electric Company, will serve as installing engineer for the Government. Mr. Jewett was connected with the installation of the Cauvery plant and his selection as erecting engineer for the Jhelum River installation comes as a well-deserved recognition of his ability.

THE EVOLUTION AND DEVELOPMENT OF THE STEAM LOCOMOTIVE AS EVIDENCED BY THE EXHIBITS IN THE TRANSPORTATION BUILDING AT THE ST. LOUIS WORLD'S FAIR.*

BY WILLIAM A. DOBLE.

PART II.

It is interesting for us to observe that so far as safety was concerned the construction of the engines of the "Planet" class was such that they were practically as safe at their proper working speed as any modern locomotive.

In the "Mercury" Stephenson so varied the frame as to be above the driving axle. Later, a small pair of trailing wheels was added behind the fire-box, and the "Mercury" became a six-wheeled locomotive, the prototype of the English standard locomotive so familiar today.

The first locomotive to be successfully run in New York state was the "De Witt Clinton," shown in Figure 28 with a train of a tender and three coaches. The original engine and train were exhibited by the New York Central and Hudson River Railroad Company, and stood by the side of the Empire State Express. The "De Witt Clinton" was built in 1831 at the West Point Foundry on the order of John B. Jervis, and made a very successful trial run on Aug. 9, 1831, from Albany to Schenectady and return. Soon after that it was put into regular service on the Mohawk and Hudson R. R. The engine has two cylinders, 5½x16 in., set at the back end of the boiler on an incline. They drive a cranked axle and there is an outside connecting rod between the drivers. The boiler is of the multitubular type, having copper tubes 2½ in. in diameter and six feet long. The fire-box drops down below the boiler and has two fire doors, one above the other. The engine weighs 3½ tons. It is fitted with very large driving wheels which have wrought iron tires and spokes. The speed of this locomotive was considered, and was remarkable, as it made thirty miles an hour with its train. It is reported that on the initial trip the sparks from the little wood-burning locomotive were so thick that the passengers were compelled to raise their umbrellas. Naturally the cloth coverings soon caught fire and the enthusiastic travelers were nearly incinerated before the journey ended.

Stacey Costell, the builder of the locomotive shown in Figure 29, was a man of very decided ability as a mechanic, and while the novelty he designed in the shape of the vibrating-cylinder steam engine had but the one application in the locomotive construction, it had considerable reputation in its day and has come down to the present time in the little engines sold in the toy shops for a dollar or thereabouts.

The "Costell" locomotive was built in Philadelphia in 1831 and took part in the B. & O. competition. It had connected driving wheels thirty-eight inches in diameter, with two six-inch cylinders of twelve-inch stroke. The cylinders were attached to right-angle cranks on the ends of the counter shafts, and from each shaft a spur and gear wheel connected with one of the axles. The boiler was of the "Cornish" type, with the fire inside of an internal straight flue. Behind the bridge wall of the boiler and inside the flue, water tubes were placed at intervals, crossing each other after the manner of the English "Galloway" boiler of the present day. The peculiar arrangement of the "Costell" made it possible to use a very simple and efficient mode of reversing. Between the steam pipe and cylinders was inserted a disc arranged with certain openings which changed the direction of the steam and exhaust by its movement against a face on

FIGURE 22. "ROCKET" WINNER OF LIVERPOOL AND MANCHESTER PRIZE, STEPHENSON, 1829

*A paper read before the Pacific Coast Railway Club, San Francisco, Cal., September 16, 1905.

the steam pipe near the cylinders, something after the manner of a two-way cock.

After the return of the locomotive from the tests at Baltimore, it was tried several times upon the Columbia R. R. at Philadelphia, and subsequently the boiler developed very good steam-making qualities. It was used for a long time as a stationary engine.

The "York" was declared the best engine in the B. & O. trial of 1831, but it was by no means a successful lomomotive as it first came from the shop of Davis & Gardner at York, Pa. As a matter of fact

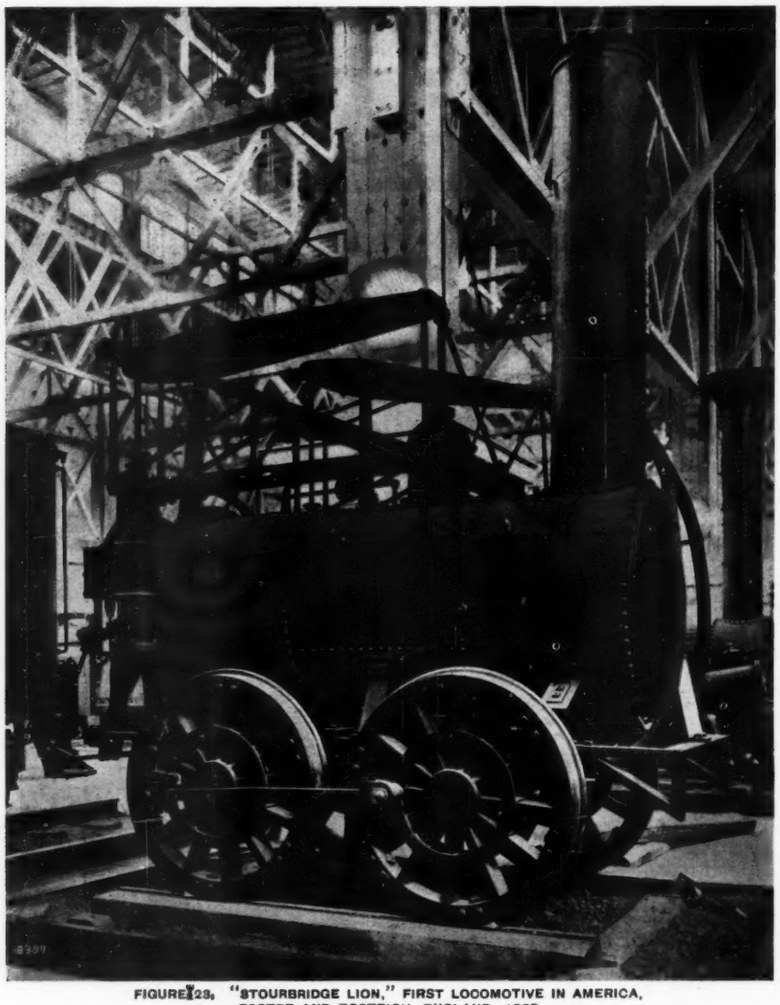


FIGURE 23. "STOURBRIDGE LION," FIRST LOCOMOTIVE IN AMERICA, FOSTER AND ROSTRICK, ENGLAND, 1829

it did nothing to speak of in the way of actual demonstration of practical utility in railroad service until it was almost completely reconstructed on the lines suggested by Ross Winans, who at the time was assistant superintendent of machinery of the B. & O. R. R.

The upright, or cheese boiler, was retained, with some changes in the internal construction. The cylinders, however, were removed altogether from the sides of the boiler and placed in front of the boiler so as to connect with the spur and pinion gearing on the axle of the road wheel, instead of the trussed side bars. The wheels were cast iron, thirty inches in diameter, the axles revolving in friction wheels of Winnan's patent. The spur and pinion gearing (the pinion on the axle of one of the road wheels) was introduced to increase the velocity. Figure 30 shows the remodeled "York."

A speed of thirty miles an hour was attained on straight lines, and fifteen miles over curves of four hundred feet radius. The fuel was anthracite coal, and a draft sufficient to burn it was obtained by means of a fan blast. The weight of the engine was but three and a half tons, and because of its consequent comparatively insignificant tractive power, it was only capable of conveying fifteen tons at the rate of fifteen miles an hour.

It was put in service upon the thirteen miles of track between the city of Baltimore and Ellicott's Mills, about five miles of which distance had an ascending grade of about seventeen feet per mile. The usual time for one trip with four cars, making a gross load of fourteen tons, was one hour.

The next engine (Figure 31), "Old Ironsides," is of special interest to American readers by reason of its having been the first to bear the name of Matthias W. Baldwin of Philadelphia, the founder of the largest locomotive works in the world. This engine dates from 1832, and was remarkable because of its construction rather than because of any novelty in its design, as it was not markedly different from Stephenson's "Mercury" of 1830. When we consider the then entire absence of facilities for doing work of this character in Philadelphia and of mechanics acquainted with any work comparable with it, we can understand the real merit of its production. Thus the cylinders were bored with a chisel fixed in a block of wood and turned by hand. Baldwin had to devise most of the methods of doing the work and do much of it himself. The engine was built on order for the Philadelphia, Germantown & Norristown Railroad, the order having been given because of the successful working of a miniature model which Mr. Baldwin had made for a museum in Philadelphia in 1831.

The final result was a locomotive comparing most favorably with Stephenson's. Three days after the trial trip it was put into service and did duty for over a score of years. The name plate, the number plate, and one of the levers on the reproduction exhibited are from the original "Old Ironsides," being the only parts of that engine known to exist.

The oldest American locomotive in existence and the only pioneer engine on American roads either of American or foreign construction is the "Atlantic,"

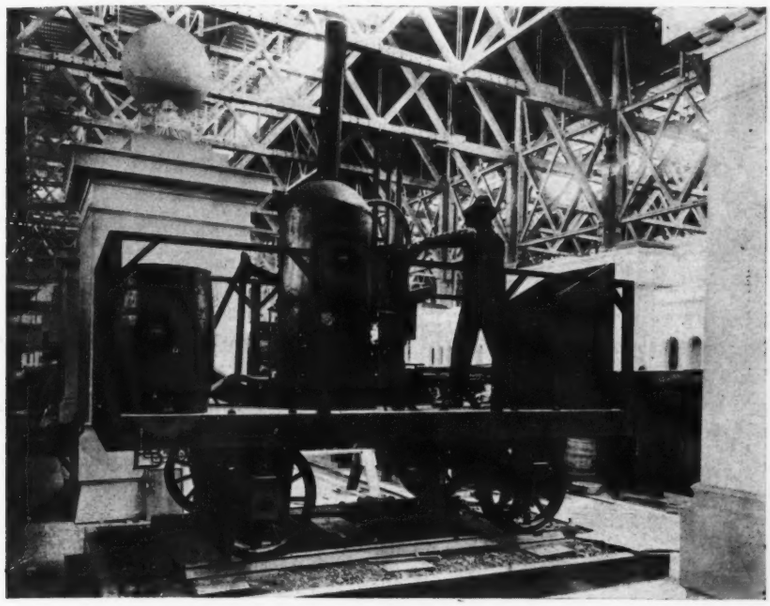


FIGURE 24. "TOM THUMB," FIRST LOCOMOTIVE BUILT IN AMERICA, 1829

(Figure 32) or the "Arabian," as it was originally called, designed and built by Phineas Davis of York, Pa. This is the father of the standard "Grasshopper" type and the pioneer of locomotive power on the B. & O. R. R. The original engine was shown at St. Louis. It was not taken out of service until it was taken to the Chicago Exposition in 1893, its active life covering thus a period of sixty years, which is believed to be an unequaled record. In this, as in many of the early Baltimore & Ohio locomotives, there is a geared connection between the engine shaft and the driving shaft, but, unlike the first efforts in that direction, in this case the gears are arranged to increase the speed.

Except for the "Johnson" there is nothing noteworthy about these early American engines, beyond the fact that they were pioneers, as they introduced no new principle of construction which endured; and, with the exception of "Old Ironsides," they were clearly inferior to English engines of the same date. With the next illustration, however, there begins another story.

Figure 33 shows the "James," which was designed and constructed by Wm. T. James, of New York, in 1832. It is noteworthy as being the first locomotive ever made with the shifting-link motion now so generally used the world over. It antedates by thirteen years the Howe, or as it is generally called, the Stephenson link.

There were in this engine two cylinders of ten inches diameter by ten-inch stroke, set at an angle of thirty degrees from a horizontal line on a wooden frame, the cylinders being surmounted by steam chests. The slide valves were worked by four fixed eccentrics and curved shifting links, the links being controlled by a reverse shaft and hangers. The upright reverse lever was surmounted by an iron ball or weight, so that when the link was required to be up or down or forward or backward motion the ball or weight would be sufficient to hold the link in the desired position. No arrangement was made to hold the link in any intermediate position for the purpose of cutting off, the link being designed for easy and sure reversing. The link was not designed as an expansion gear, its use for such purpose being discovered accidentally by Samuel B. Dougherty, who was James' foreman, while setting the valves.

The James locomotive was built in 1832, was taken to Baltimore early the following year and run on the B. & O. until 1835, when it was returned to New York and placed on the Harlem Railroad, where it shortly after exploded.

In connection with this illustration it is interesting to note that the engine is mounted on a portion of the original track of the B. & O., which was laid in 1829. The rail, which was laid upon granite sills, was of the strap or bar-iron type so generally used throughout the country in the early "thirties," it being two and a half inches in width and five-eighths of an inch

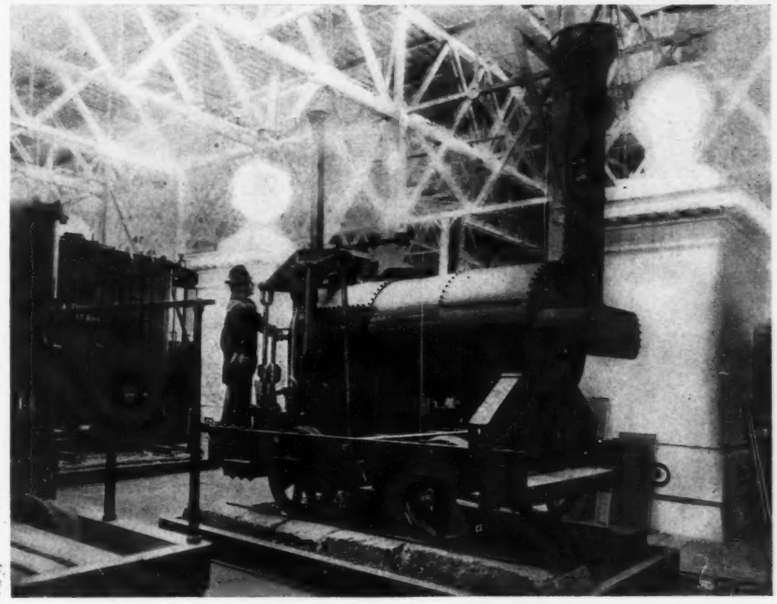


FIGURE 25. "GEO. W. JOHNSON," PIONEER OF WALKING BEAM TYPE, JOHNSON, 1830

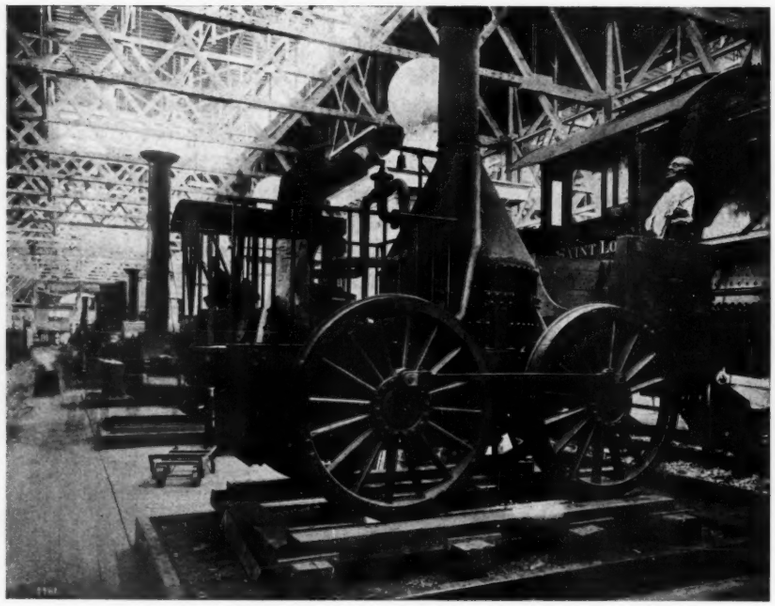


FIGURE 26. "BEST FRIEND," FIRST LOCOMOTIVE BUILT FOR ACTUAL SERVICE IN AMERICA, MILLER, 1830

in thickness. The sills were of almost any and every dimension as they were quarried, though some effort was made to get them of a fair corresponding width when being prepared for the edge on which the rails were fastened.

Next we have the "South Carolina," (Figure 34) designed by Horatio Allen of New York, built by the West Point Foundry Works, in 1832, and the first eight-wheel locomotive in the world. It was also the first double horizontal-boiler locomotive in the world, the first double-ender, and the father of the "Fairlie" type so largely used in Europe.

Horatio Allen was the pioneer locomotive engineer of America, and the first to make a practical study of the locomotive and its adaption for American railroads. He was the first to import a locomotive from England, and the first to run one on American soil, the first to design one for actual service, and was chief engineer of the first railroad in the world to decide to build for locomotive power.

It is obvious at a glance at the illustration that the "South Carolina" was of far greater power than most engines of its time. Moreover, it introduced the Fairlie principle, which has found considerable use in Europe, and it foreshadowed the bogie truck. The engine had a long, double boiler with a single fire-box and rode on two trucks which were arranged to swivel in order to accommodate curves, as all trucks do now. Each end had a single cylinder under the smokebox, the swiveling of the truck being taken care of by looseness in the crosshead and crank pins. The "South Carolina" was assigned a place on the South Carolina Railroad early in 1832.

The year 1832 saw the construction of many of the pioneer locomotives, but none was of more importance than the "Experiment" (Figure 35) which was built by John B. Jervis of New York, and in which the complete "bogie" or forward truck first appeared.

Jervis, who was chief engineer of the Mohawk and Hudson Railroad, had been studying the work of the "De Witt Clinton" and was impressed with the unsuitability of the rigid wheel base for the sharp curves which were a necessity in this country. Up to this time both English and American practice had used the rigid wheel base. Jervis speedily solved the difficulty by the invention, or if not strictly such, the adoption of the bogie or wheel truck, introducing it in the locomotive built from his drawings and specifications at the West Point Foundry Works, New York. This was the first locomotive in the world so constructed. There were four wheels in the

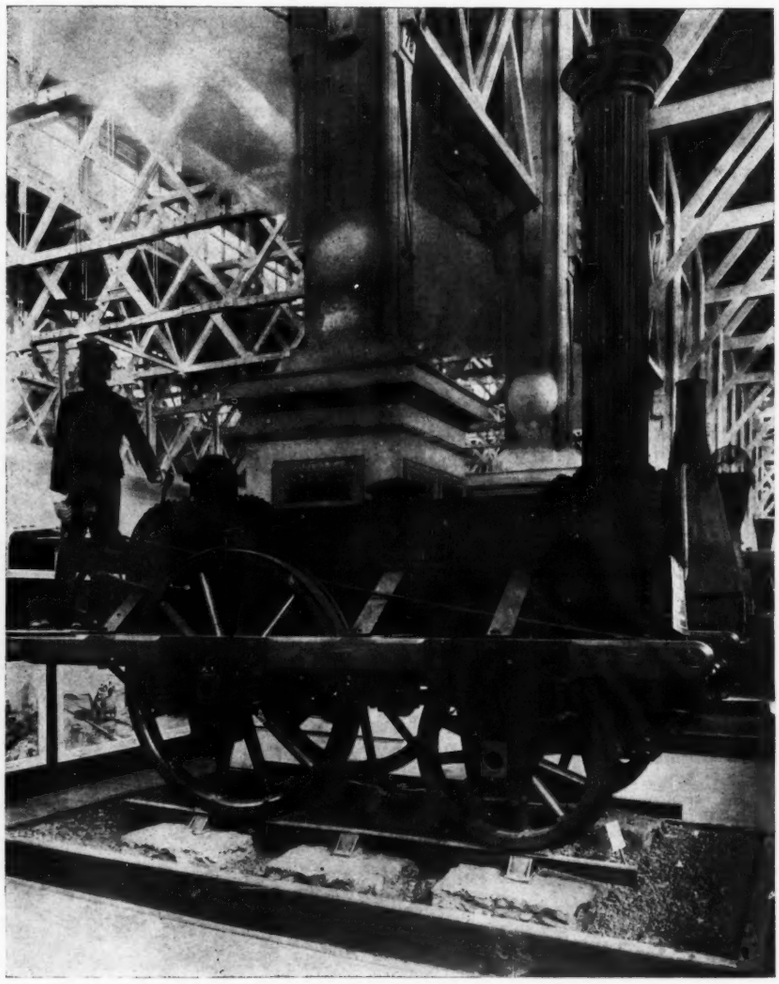


FIGURE 27. "MERCURY," HIGHEST DEVELOPMENT OF "PLANET" TYPE, STEPHENSON, 1830

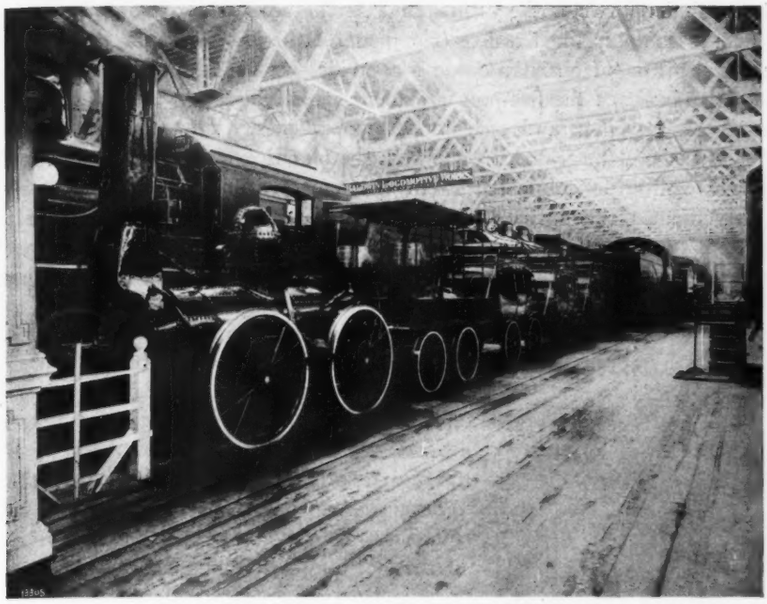


FIGURE 28. "DE WITT CLINTON," FIRST LOCOMOTIVE RUN IN NEW YORK STATE, JERVIS, 1831

truck, which was placed under the front end of the boiler for support, attached by a strong pin and worked upon friction rollers, so as to easily follow the curves of the road.

This locomotive had a remarkable record for speed, having made fourteen miles in thirteen minutes, and a single mile in fifty seconds,—and this over seventy years ago. The underhung spring rigging on this engine was unusual at the time, and was not used to any extent until comparatively modern times.

In connection with the Louisiana Purchase Exposition, it is interesting to note that the original "Mississippi," (Figure 36) the first locomotive seen in the Louisiana Territory, was on exhibition. This locomotive was built in England in 1834 and ran between Natchez and Hamburg, Miss., in 1836-38.

This is the first locomotive to have a cab, but it is not known whether this was part of the original design or not. From its general appearance it was evidently for a southern climate and probably was put on after the engine reached this country. In general features, the construction shows more modern ideas than were apparent in the other engines of that time, and it has probably been changed in many respects from its original form.

Figure 37 shows the "Jefferson" which was the first locomotive built by Ross Winans of Baltimore, Md. This locomotive is of the Dan's type and was exhibited just as it came out of the B. & O. service at the Mount Clare Yard, after fifty-eight years of continuous duty.

This locomotive was the fullest development of the "Grasshopper" type, the improvements consisting chiefly in details relating to the steam and exhaust openings, and pipes and action of the slide valves which continued to be worked by cams.

Winans built, in all, ten "Grasshoppers" for the B. & O., making a total of seventeen of such type in service, and so satisfactory was their performance that it rarely happened that more than two of them were in the shops at one time for repairs. The cab and tank were added to this engine, and were not original portions of it.

The next is the "Mazeppa" (Figure 38) built in Baltimore by Winans in 1836, and the first of the "Crab" type. The original engine was shown in its original form after being in service for half a century.

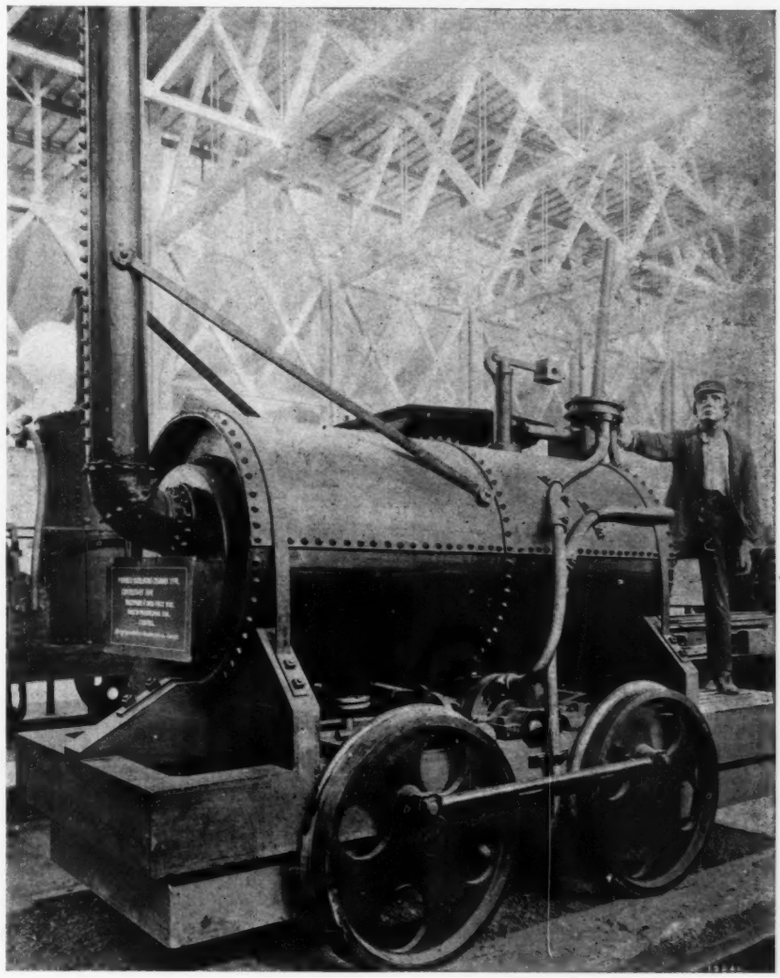


FIGURE 29. "COSTELL," PIONEER OSCILLATING CYLINDER TYPE, COSTELL, 1831

It is in reality a "Grasshopper" with the cylinder changed from vertical to horizontal and attached to the back end of the frame instead of the front end, thus giving the machine, when at rest, the look of a crab moving backward instead of forward. The altered position of the cylinder worked well upon the whole, but the engine being still supported only on four wheels, with axles scarcely more than four feet apart, its movement, at speed, was unsteady.

The first locomotive seen in Chicago was the "Pioneer." Figure 39 shows the original engine which ran on the Galena and Chicago Union R. R., now a part of the Chicago and Northwestern R. R. It made its first trip in Chicago on Oct. 10, 1848, but was built by Baldwin in 1836, being the 37th engine turned out of those shops. It was originally intended for the Utica and Schenectady R. R. but was purchased by the Galena and Chicago Union R. R. from the Rochester and Batavia R. R. and shipped to Chicago by boat.

FIGURE 30. REMODELED "YORK," PIONEER BOTTLE BOILER TYPE, DAVIS, 1831

The cylinders are 11x18 in. and the drivers 54 in. in diameter. It weighs 24,000 lbs. The main frame is flat, double in the rear and single ahead, and is outside the wheels. The cylinders are fastened on the incline, between the frame and smoke-box, and drive through a cranked axle. The usual Baldwin design at that time, of circular dome topped fire-box and single driver back of the fire-box is evident. The valve-gear is rather complex and consists of two eccentrics on the axle outside the frame, from which the blades extend forward and can be connected to or disconnected from the rocker arm through a hook arrangement connected to a reverse shaft and lever. Thus either the forward or backward eccentric can be put into operation as desired. The cab is very much the same shape and style as is in use at present.

Another famous engine of that day was the "Lafayette," (Figure 40) built by Wm. Norris, of Philadelphia, in 1837. This was one of three, which were the most noted locomotives of their time, chiefly because of their great adhesion. One of the two, the "Washington," performed what had been believed to be impossible in climbing grades on the Baltimore & Ohio. The success of these engines was so great as to lead to an order from England for an engine for use on the Lickey Incline of the Birmingham & Glouchester Railway, where chain or cable traction had been used. The engine built to fill this order was the "Philadelphia," which was the first American locomotive to be exported, and which was so successful that five more were ordered, and the cable system was abandoned upon this incline. One of these locomotives drew 100 to 120 tons on an incline of 1 in 33 at 14 to 23 miles per hour. A large demand for Norris engines continued in Europe, and eventually led Mr. Norris to establish himself in Australia, where he built the Royal Works at Vienna.

In the "Lafayette," shown in this view, we see the typical American engine beginning to take shape, for here are the bogie truck, the outside cylinders and the bar frames. The secret of its greater tractive power appears to lie in the location of the driving wheels in front of the fire-box. Baldwin engines of that date had their driving wheels behind the fire-box, and, of course, with the Norris arrangement these wheels carried a greater percentage of the total weight than they did in the Baldwin position.

By 1836 the period had arrived when the increasing of business on American railways demanded a corresponding augmenting of the power of the locomotive. It had for some time been realized that for freight traffic particularly, the engine with a single pair of drivers was insufficient to meet the steadily increasing trade where lines had been completed.

Baldwin's locomotives had the single pair of drivers placed back of the fire-box, while the locomotives built by Norris had the pair of drivers in front of the fire-box.

The Norris engines at this period were in power and strength of adhesion undoubtedly the most successful built, either upon this side of the Atlantic or the other; still, as previously stated, the want of more powerful locomotives was being generally felt, and an engine with two pair of drivers, one pair in front and one behind the fire-box, was the next logical step.

Henry R. Campbell, of Philadelphia, was the first to carry this design into execution. Mr. Campbell was chief engineer of the Germantown R. R. when "Old Ironsides," the first engine, was placed on that line, and from that time had given much attention to locomotive construction. Early in February of 1836, Mr. Campbell secured a patent for an eight-wheel engine with four drivers connected, and a four-wheel truck in front, and he subsequently contracted with James Brooks, of Philadelphia, to build him such an engine.

The engine (Figure 41) known as the "Campbell," has the appearance of a modern locomotive with the exception of the frame, which is still a large rectangular structure of wood, outside the wheels. The cylinders are horizontal and located side by side below the smoke-box. They connect directly to the front axle, which is cranked. The valves are driven from two eccentrics on the main axle, and the reverse is obtained by changing the steam passage in the valve-chest by means of an auxiliary valve. There are connecting rods between the drivers from two cranks outside the frame. The boiler is not lagged, but the boiler check-valve is located very near its present place.

The first engine built by Thomas Rogers, the founder of the Rogers Locomotive Works, was the "Sandusky," in 1837. In this locomotive (Figure 42) we find the first effort toward counterbalancing. The driving wheels were made of cast iron with hollow spokes and rim. The spokes and rim opposite the crank were cast solid, giving enough extra weight to balance the crank and main rod end. This scheme was patented by Mr. Rogers, July 12, 1837. The "Sandusky" had cylinders 11x16 in. and 54 in. drivers. The cylinders were fastened to the smoke-box and connected to a cranked axle. The eccentrics were outside the frame and operated a rock shaft at the back end from which the valve rod extended the whole length of the boiler to the steam chest. The smoke-pipe was of the bonnet kind, having a deflecting cone curled over the edges in the center so as to deflect the sparks downward and thus prevent their passing through the wire bonnet.

An interesting point in connection with this machine is that it determined the gauge of the track for the state of Ohio for many years. The engine was built for the New Jersey Railroad and Transportation Co., the gauge of which track was four feet ten inches. After making a trial trip from Paterson to Jersey City and New Brunswick and return, it was sold to the Mad River and Lake Erie Railroad Co., and shipped, by canal and lake to Sandusky, before a mile of road had been built. The track was then laid to suit the gauge of the locomotive, and not long after the legislature of the State passed an act making four feet ten inches the standard gauge for the State.

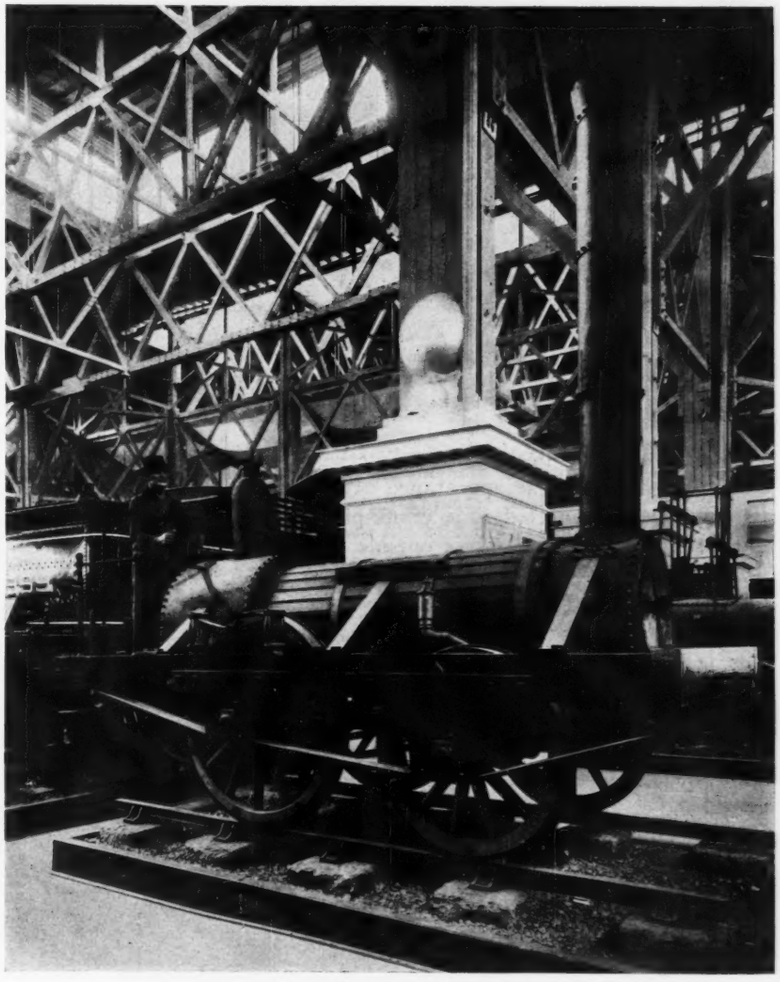


FIGURE 31. "OLD IRONSIDES," FIRST LOCOMOTIVE BUILT BY BALDWIN, 1832

The equalizing lever first made its appearance in the "Hercules," (Figure 43) designed and built by Eastwick and Harrison, of Philadelphia, in 1837. This engine weighed fifteen tons, which was considered enormous at that time, and it was generally thought that the design would be a failure in practice because of its great weight. In the original design the construction of the equalizing lever was somewhat different from that shown by this reproduction, but was soon changed to this design at the suggestion of Joseph Harrison, Jr. The original design used a separate rocking frame fulcrumed at its center on both sides. The advantage of having the two wheels on the

same axle separately equalized being pointed out, the end pieces were discarded, and we have the equalizer in almost its present form. It was connected from the center to a flat spring below the frame and from the ends directly to the driving-boxes. The appearance of the inside frame with cylinders connected to a crank-pin on the wheels and fastened to the smoke-box outside the frame should also be noted on this engine. The valve gear worked from eccentrics on the rear axle through a rock-shaft and long valve rods. This body of the boiler was lagged with wood, but the dome and fire-box were not.

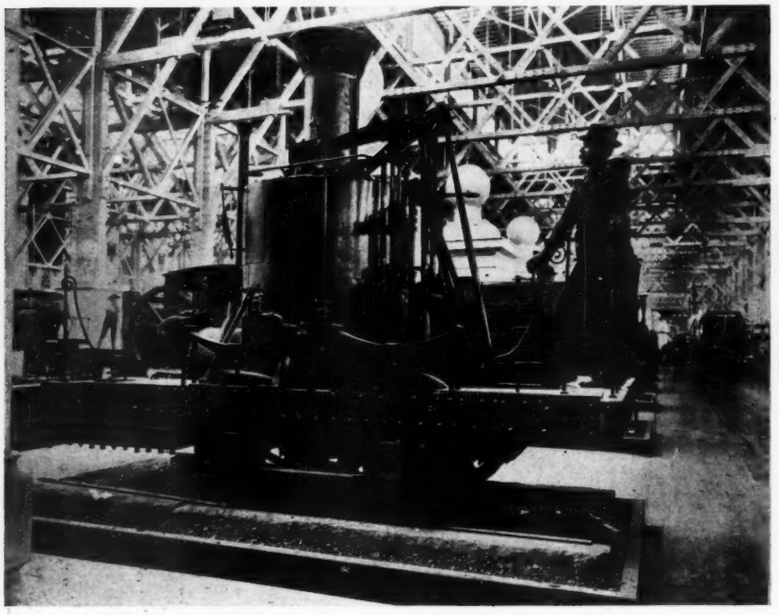


FIGURE 32. "ATLANTIC," FIRST OF "GRASSHOPPER" TYPE, DAVIS, 1832

The "Hercules" was the first to have eight wheels, and in it we see another long step in the evolution of the American locomotive. Here we have the bogie truck, the outside cylinders, the bar frame, the equalizers, and the four connected driving-wheels; however, the frame is composite of wood and iron. With the addition of the cab, the link motion, the saddle, and the touch of the refining hand of William Mason, we have the American eight-wheel locomotive of today.

The "Rocket," (Figure 44) the first to be used on the Pennsylvania & Reading Railroad, was built in England in 1838 by Braithwaite, who, in conjunction with Ericsson, built the "Novelty," one of the competitors in the Liverpool & Manchester trial of 1829. The "Rocket," as exhibited, was the original locomotive in the main essential parts.

With the locomotive shown in Figure 45, we go back again to the name of Timothy Hackworth, of England. This engine, the "Samson," was built by him in 1838, and, except for the "Sans Pareil," is among the oldest of Hackworth's locomotives. The "Samson" was installed on the Albion Mines Road, connecting Stellarton and Pictou Harbor, in Nova Scotia in 1838, and continued in use for forty-five years.

The engineer's post is at the front end of the engine, so that he can keep a good lookout ahead, while the fireman's place is at the rear, the boiler having the single return flue of the "Sans Pareil." The sand-box consisted of two buckets of sand, one at each end of the locomotive, the sand being thrown by hand on the rails. The gauge-cocks and the steam-gauge are upon the side of the boiler, and the engineer had to leave his post in order to inspect either. The cylinders are vertical within a housing at the engineer's end, the piston-rod being fitted with a parallel motion instead of a cross-head, and the brasses now in place in connection with this link-work are said to be the original ones. It is sufficiently obvious from the illustration that this engine of Hackworth's was no toy.

Attached to the "Samson" will be seen an old passenger car which came from the same road, and which is undoubtedly the oldest passenger car upon the American continent, and in all probability the oldest in existence. It was ordered at the time the locomotive was ordered, and, although the order comprised but one car, it involved a good deal of correspondence. The car was attached to the rear of the ordinary coal trains in order that those

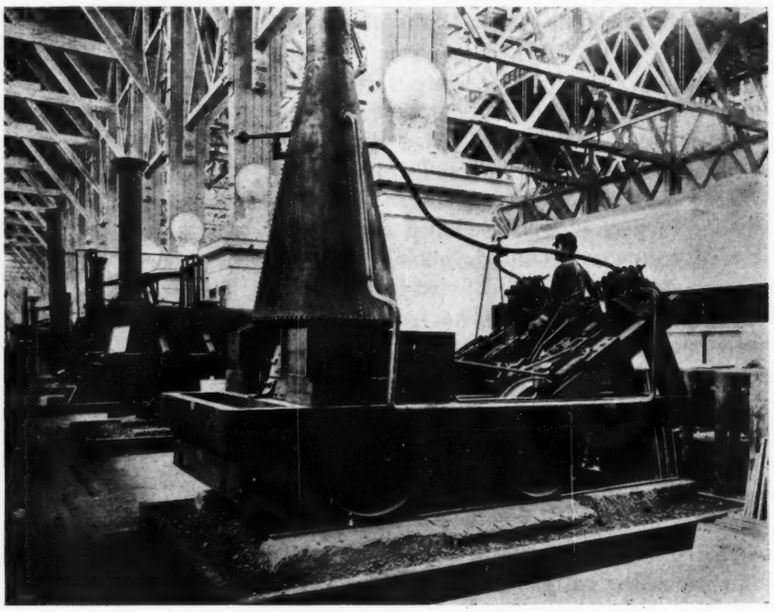


FIGURE 33. "JAMES," FIRST LOCOMOTIVE WITH LINK MOTION, JAMES, 1832

who wished might ride. The next locomotive (Figure 46) is the "Albion," designed and built by Hackworth in 1839, for the Albion mines in Nova Scotia, where, like the "Samson," it was in service many years.

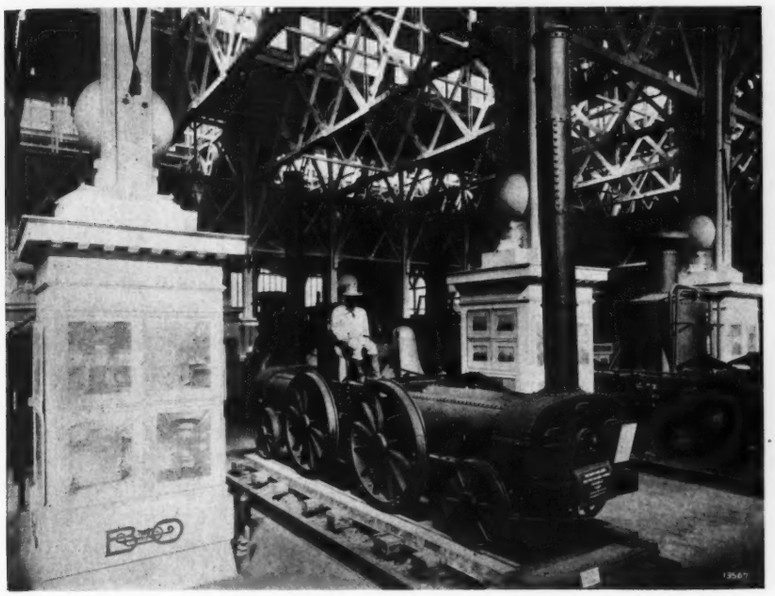


FIGURE 34. "SOUTH CAROLINA," FIRST EIGHT-WHEEL AND FIRST DOUBLE HORIZONTAL BOILER, ALLEN, 1832

To the modern locomotive engineer, the cabless engine would indicate hardship of no ordinary nature, but old engine drivers, still living, affect to scorn the modern machine with its complicated gauges, airbrakes, and the like. A short time ago one of them, in speaking of his long service in the United States on Hackworth's locomotives, states, "All the wind and snow of forty years never made old 'Donald Thompson' shiver yet," and to a further inquiry responded, "indeed I was far more careful of her than the good wife."

Figure 47 illustrates the "Buffalo," an experimental locomotive, designed and built by Ross Winans, of Baltimore, Md., in 1844—the first eight-wheel coupled locomotive in the world. This engine was called the "Mud Digger," because the coupling rod of the wheels reached down so close to the track.

Next we have the "Mount Claire," (Figure 48) designed and constructed by James Murray, of Baltimore, in 1845, the first locomotive built by the B. & O. R. R. Co.

Mr. Murray, who at the time of the exposition, was residing with Mr. Winans in London, England, in writing of the "Mount Claire," says, "this engine was designed by me, and built in the company's shops, the object being to remodel certain defective matter relating to the valve gear and to the position of the spur and pinion wheel of the Winans geared locomotive at a time when we still had a little less than two and a quarter by five-eighths of an inch flat bar rail on a wooden string-piece between Baltimore and Harper's Ferry, and feared to introduce larger wheels and greater speed of wheel-base than had previously been determined practicable.

"The cylinders were placed inside, immediately under the smoke-box, the wheels having a diameter of thirty-five inches, and the gearing so proportioned as to make them equal to fifty inches in diameter.

"The valve gearing did not embrace 'cams' as this was a fault in the Winans geared engine which I intended to avoid. The valves had considerable lap on the induction sides and there was an arrangement on the back of the valves by means of which the steam could be cut off at about half-stroke."

Mr. Murry designed and constructed, at Mt. Claire, the first round-house in the world for the protection of locomotives, with a turntable in the center.

He went to Russia with Ross Winans when the latter closed the contract with the Government of that country for the construction of railroad locomotives, and has since been closely identified with Winans' family.

Figure 49 shows the "Camel Back" of 1848. It was the first of its type and was built by Ross Winans. It

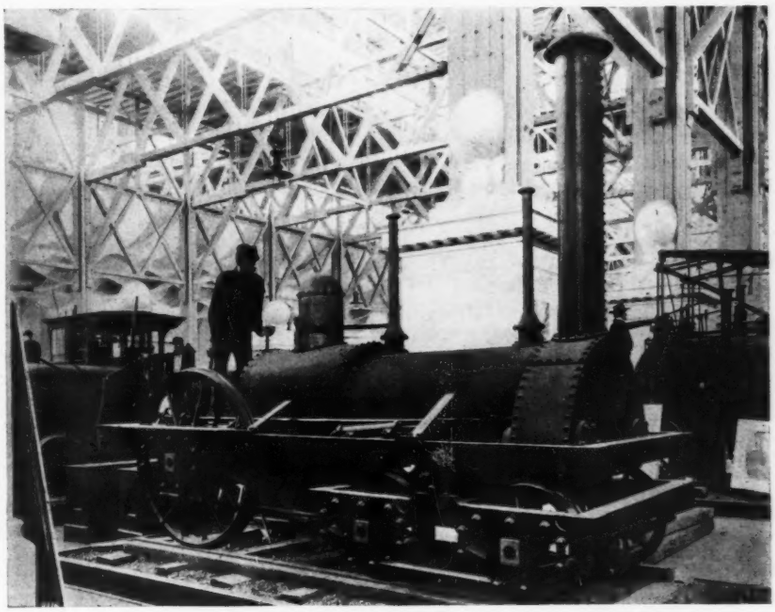


FIGURE 35. "EXPERIMENT," FIRST LOCOMOTIVE WITH FORWARD TRUCK, JERVIS, 1832

marks the beginning of heavy power and has the essential features of the modern heavy freight engine. There are eight coupled drivers and a large horizontal cylinder set outside the frames and connected to the third pair of

drivers. The frame is made of two plates set about three inches apart, and extends to the forward end of the fire-box. Double plate braces support the boiler at two points, and the fire-box, being wider than the frames, overhangs at the rear. The very large dome, surrounded by a covered platform at the center of the boiler, gives this type its name of "Camel Back." The valve-gear is very complicated and is driven by a set of cams on the main axle. The large spark-catcher and long cinder-chute on the stack add to the fantastic appearance above the boiler. This was the first engine to have sling-stays instead of crown-bars for support of the crown-sheet. As can be seen in the illustration there is a large pump at the side of the fire-box in the rear which is operated through a very long rod from the cross-head.

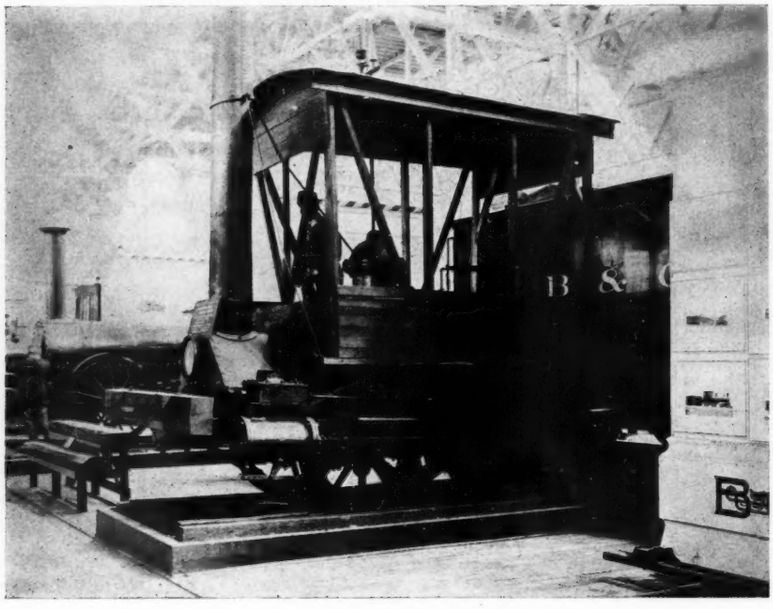


FIGURE 36. "MISSISSIPPI" FIRST LOCOMOTIVE IN LOWER MISSISSIPPI COUNTRY, 1834

In October, 1847, the B. & O. R. R. Co. advertised for proposals for four engines to burn Cumberland coal, and the order was taken and filled by Mr. Baldwin with four eight-wheeled constructed machines. Of them the "Dragon," shown in this Figure 50, was the first one which was delivered. It was exhibited just as taken out of service in the yard of the company's rolling-mills, at Cumberland, after forty-five years continued duty.

Baldwin, in the earliest years of the works, had the usual ups and downs characteristic to the establishing of a great business. He was not an impulsive man, on the contrary, was most deliberate, and he had to satisfy himself pretty thoroughly that an innovation was one that would stand the test of hard usage before he would adopt it. His first flexible-truck engine was completed in 1842 and had six wheels connected. This plan of construction was modified and improved until 1844, when the six-wheel connected engines had become so successful as to enable the increase of size up to eighteen and twenty tons weight. Within a year or so eight-wheel connected engines were built two for the Philadelphia & Reading road weighing twenty-five tons each. These were the first upon which Baldwin placed sand-boxes, and also the first upon which roofs were introduced over the foot board, up to this time a railing being the only protection offered the engine men. The lattter attached curtains at the side and front, but by the time the "Dragon" was built Baldwin had introduced the cab with sides and roof, sash and glass.

In the "Dragon" he also introduced an innovation in the shape of the grate with rocking-bar in the center, having fingers on each side which interlocked with projections on fixed bars, one in front and one behind. It was operated from the foot-board.

The next engine (Figure 51) is the "Pioneer," built in 1851 by Seth Wilmarth, who was an engine builder of some note in the early '50s. His shops were situated at South Boston, and he built many engines for the Boston & Worcester, the Hudson River, the Eastern of Massachusetts, and the Old Colony Railroads. His designs were generally patterned after the Hinckley engine of those days; but they had some points of originality, as for instance, leading and trailing four-wheel trucks, he being, probably, the first to design this wheel arrangement, which was repeated by later builders.

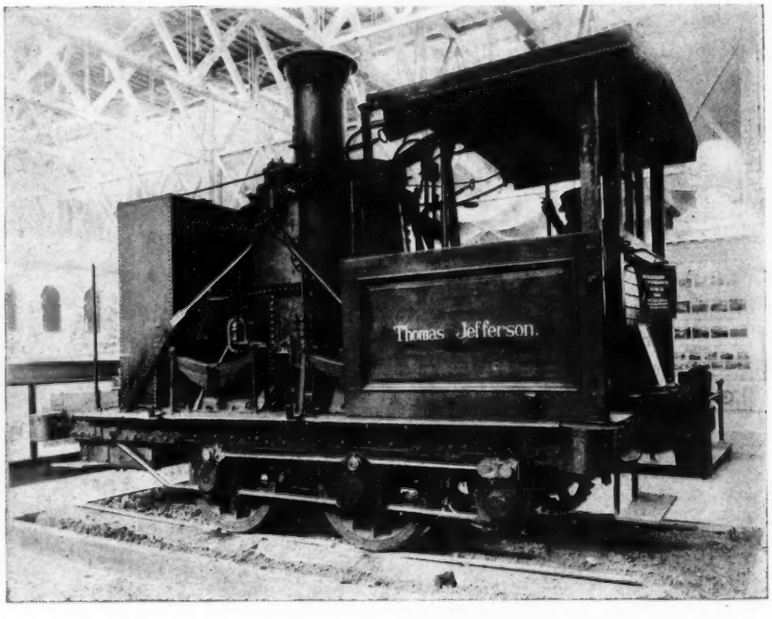


FIGURE 37. "JEFFERSON," FULLEST DEVELOPMENT OF "GRASSHOPPER" TYPE, WINANS, 1835

The "Pioneer" has cylinders nine inches in diameter by fourteen inches stroke, driving wheels forty-four inches in diameter, and weighs thirteen tons. It is a tank-engine and has a single pair of driving-wheels—types of the locomotive that are not, and never were, so common in the United States as in Great Britain. The boiler has a wagon top, and the steam and exhaust pipes come outside the smoke-box, where they enter the valve-chest at the back side. The valve-chest cover is on the front side of the chest instead of the top, and neither the pipes nor chests have any lagging. The sand-boxes are on the driving-wheel guards, but side elevations of the engine, which have been published, show a sand dome on the boiler barrel, which was probably its original position. The engine has link motion. The connecting rods and other working parts are very light, but the engine was probably never used for heavy work. It was built for the Cumberland Valley Railroad in 1851, and is said to have never been changed or remodeled. The engine ran for forty years.

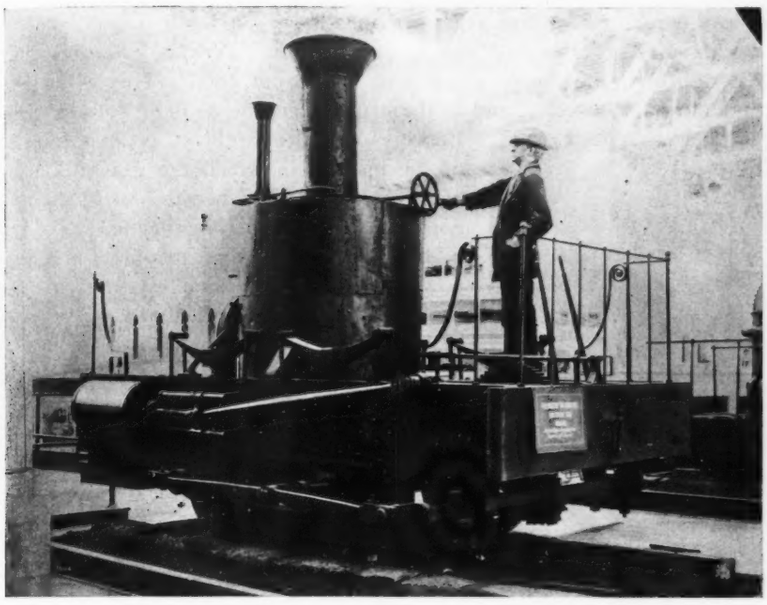


FIGURE 38. "MAZEPPA," FIRST OF THE "CRAB" TYPE, WINANS, 1836

The engine shown in Figure 52, the earliest of the ten-wheel "Camel" type of locomotive for heavy traffic, has seen actual service for the extended period of forty-one years, well along toward thrice the usual age which engines, especially those in freight service on steep grades, are generally accredited.

There is no question as to its condition for further work, and the chances are that had not the engine been withdrawn to be made a part of the B. & O. collection, it would have rounded out a full half century of continuous duty.

Few if any railroads in the world have necessitated the construction of heavier and more substantial power than the Burlington and Ohio, and none have created or perfected types of locomotives making such records for continuous service. Its Mount Claire Shops at Baltimore have established a remarkable reputation in this report.

The ten-wheel "Camel" for mountain grades and heavy yard service, has demonstrated extraordinary good qualities, being powerful, easy on steep grades, and burning anthracite coal very economically.

The original "Camel Back," invented by Ross Winans, was on eight wheels coupled. By substituting a four-wheel truck for the forward pair of drivers as shown in this engine, a much more satisfactory result was obtained on sharp curves.

Figure 53 shows the earliest example of the Mason type of locomotive now in existence, being designed and built by Wm. Mason, of Taunton, Mass., in 1853.

Mason was without doubt, the pioneer, in fact may truly be said to have been the father of the present symmetrical American type engines. He placed the cylinders outside the lever and perfected the wide-spread truck; he introduced lines of beauty in general construction, which, up to his day, no one appears to have given a thought. He changed the uncouth form to one of grace and finish, and the domes and sand-boxes of his design added to, rather than cumbered, the style of his construction. Mason made a cab neat and appropriate, to harmonize with the finish as a whole. In doing this he brought about such com-

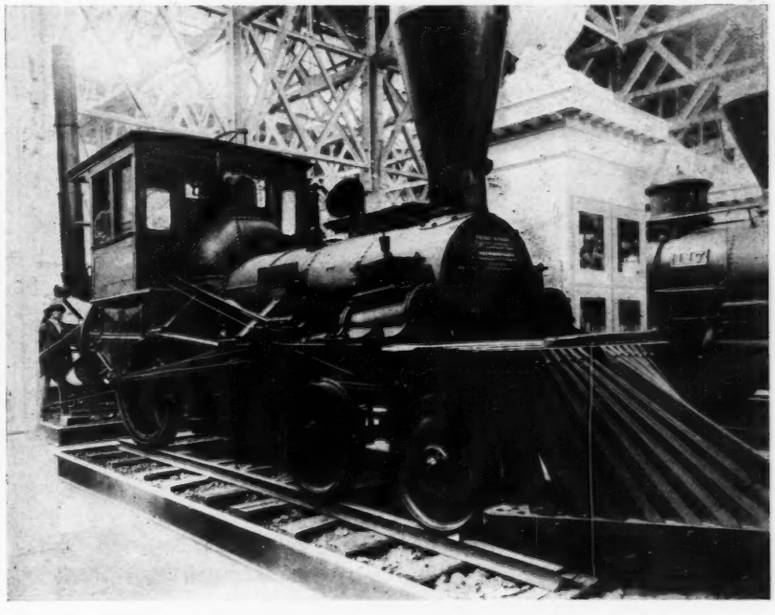


FIGURE 39. "PIONEER," FIRST LOCOMOTIVE IN CHICAGO, BALDWIN, 1836

bination of forms and lines to render the whole in artistic unison, and in thus showing what could be done when the effort was intelligent and determined, stimulated others to follow. The result of his good work is the general symmetry and grace that distinguishes the American locomotive above all others—at least in American eyes.

With all his regard for perfect proportions, symmetry of lines and fine finish, Mason by no means lost sight of the highest essentials in locomotive construction, and

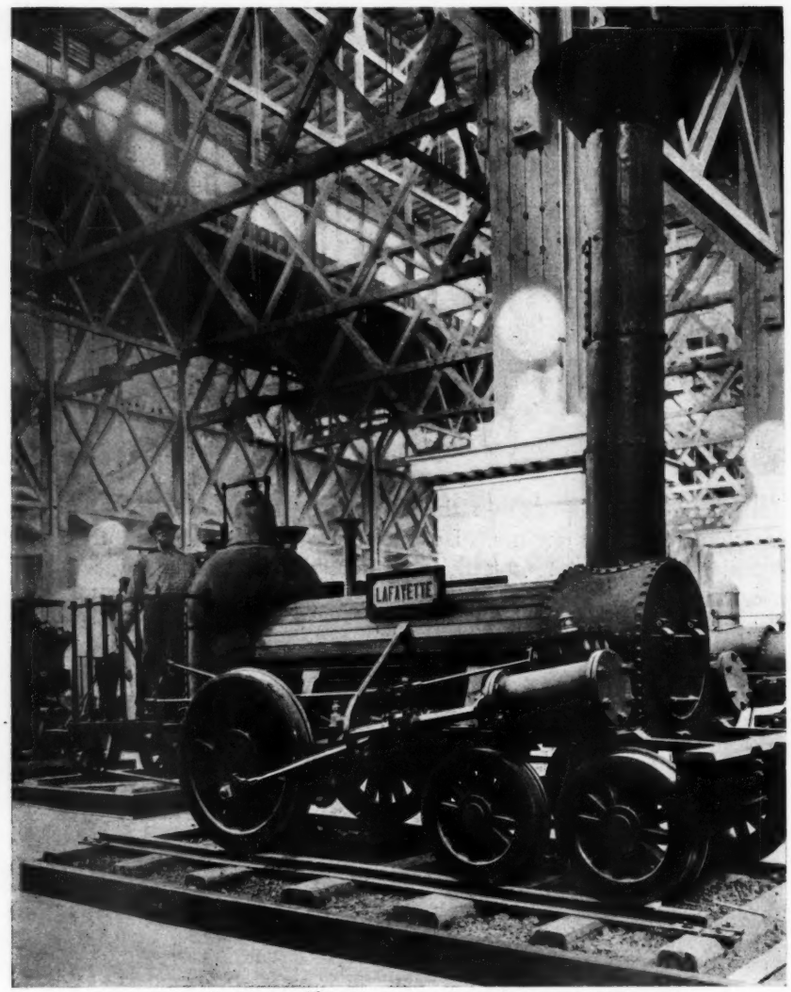


FIGURE 40. "LAFAYETTE," NOTED FOR ITS GREAT ADHESION, NORRIS, 1837

those of his build were noted for their endurance, and meeting demands of actual service. He was a superior mechanic, and it was characteristic of him that whatever he did was thoroughly well done.

The greatness of his work may be best appreciated by contrasting this locomotive with the uncouth forms that preceded it, and also by recalling that it standardized the American locomotive for many years. Indeed, the name given to this type of engine—the "American"—is most significant of the influence which Mason had upon American locomotive practice. Remove the moldings from the steam dome, sand-box, and cab, and replace them with the present rounded forms, and there is not an important line in this whole engine that would not be considered modern to-day.

Recalling that but twenty-four years intervened between the "Rocket" and the "Mason" and sixteen years between the "Hercules," you will understand that rapid progress is not exclusively a matter of our day. The contrast between the "Mason" and Baldwin's "Pioneer" of but five years previous is very striking.

The next step is shown in the "Perkins," (Figure 54) the heavy grade type in use in 1864. This is a ten-wheeler, and is the original engine as built by Thatcher Perkins of Baltimore. It is an example of the manner in which the graceful lines of Mason's engine became permanently popular. When it became necessary to get more weight on drivers and more hauling power it was a very simple matter to put in another driving wheel ahead of the two of the American type, and it was generally done when more power was needed. This locomotive of Perkins had the large flaring stack of that period, but in other respects it does not differ materially from the many small ten-wheelers in use over the country at the present day.

The "Perkins" is the earliest example of the type of locomotive now in general use for heavy passenger trains running upon fast schedules. Its details of construction are as follows: Center to center of cylinders, 80 inches; out to out of frames, 56 inches; size of fire-box, 34 by 84 inches; length of tubes, 12 feet 4¼ inches; diameter of tubes, 2¼ inches; number of tubes, 138; grate area, 19.8 square feet; total heating surface, 1,113 square feet; total length over all, 53 feet.

In Figure 55 we have the "Peppersauce," the first mountain-climbing or rack locomotive ever built. This is the original engine designed by Sylvester Marsh in 1863, for use in climbing Mt. Washington. It was built by the Whitten Machine Company of Boston. The boiler is hung on trunnions in order that it may remain upright on the level or any grade, and the steam connection and boiler feed-pipes are connected through these trunnions. The cylinders are outside the frame, which is carried on four wheels, and drive a crank-shaft which is geared to the driving-shaft. The toothed gear on the driving-shaft engages the rack laid between the rails. There is also a gear-wheel on the back axle which engages the rack and is used in connection with a band brake for control in going down the mountain. The "Peppersauce" had neither pump nor tender. It was fitted with three water gauges, one near the top, one about midway, and the other just over the fire-box.

Walter Aiken, President of the Mt. Washington R. R. and identified with it practically from the start, writes: "We used to fill the boiler about full, run her up with material until the water was about out of her and then

let her back, let the steam down, unscrew a plug, put in a funnel and fill her up with water again." Mr. Aiken added a pump and a tender, and for ten years or more the "Peppersauce" did good service.

One of the last trips it made was with the late Wm. H. Vanderbilt, who conceived the idea of eating his breakfast at the Profile House, dinner on the summit of Mount Washington, and supper back at the Profile House. It was the intention to use another engine, but owing to something going wrong, the "Peppersauce" had to be steamed up, and although as Mr. Aiken says, "She leaked around every tube, and constantly lost steam, Mr. Vanderbilt was able to carry out his program, and he and his family were the first to accomplish the trip as indicated prior to the construction of the railroad from the Profile House to the base of the mountain."

General Grant made his first ascent of Mt. Washington in a car drawn by the "Peppersauce," and many of the most distinguished men of this country as well as noted visitors from abroad, have gone up the mountain behind this, the first of the mountain-climbing locomotives.

The locomotive shown in Figure 56, the B. & O. "600," is of particular interest as it is the engine exhibited by the B. & O. R. R. at Philadelphia, in 1876, as an example of a fast passenger locomotive. It is of the "Mogul" type and was the heaviest passenger engine in the world at that time. It will be noted that the pump for boiler feed was still in use in 1876. In this case it was connected to the rear driver, but the usual custom was to drive it from the cross-head.

The principal data of the "600" are as follows: Diameter of cylinders, 19 inches; stroke of piston, 26 inches; diameter of driving wheels, 5 feet; wheel base of engine, 22 feet and 11 inches; number of boiler tubes, 165; grate surface, 23 feet 7 inches; total heating surface, 1,272 square feet; weight of engine in working order 90,400 pounds; weight on driving wheels 76,550 pounds; weight of tender loaded, 60,400 pounds; total weight of engine and tender ready for service, 150,800 pounds; in round figures 76 tons.

Coming down to the World's Columbian Exposition of 1893, we find the "Director General," (Figure 57) a Vauclain four-cylinder compound locomotive of the American type which was exhibited at Chicago. This was considered a very large passenger engine in 1893, but looked rather small in comparison with the more modern locomotives shown at St. Louis.

It has 13½ and 23x24-in. cylinders, and 78-in. wheels, and weighs 122,780 lbs. total. The boiler is 60⅝-in. diameter and has 251 2-in. tubes, 11 ft. 10 in. long, giving a heating surface of 1,544 sq. ft. The total heating surface is 1,693 sq. ft. The fire-box, between the frames, is 107½ in. long, and gives a grate area of 24.75 sq. ft. The tender carries 3,500 gallons of water and 4½ tons of coal.

The B. & O. historical collection was brought thoroughly up-to-date by the exhibition of three of its mod-

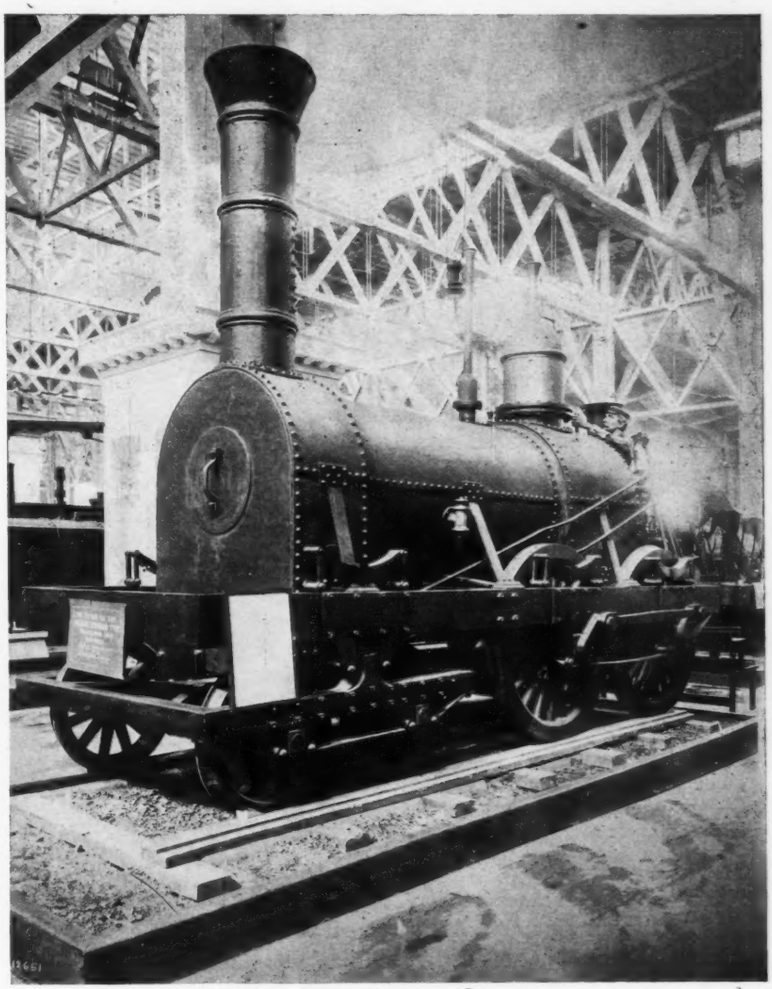


FIGURE 41. 'CAMPBELL," FATHER OF AMERICAN STANDARD TYPE, 1836

ern types of engines. One of these was a simple consolidation locomotive, built by the Rogers Locomotive Works. This locomotive was located in the exhibit of the Baltimore and Ohio Railroad and was named "Governor Francis" in honor of the President of the exposition.

A simple Atlantic type locomotive built by the American Locomotive Works, shown in Figure 58, was located in the B. & O. exhibit near the center of the building and was much admired by visitors because of its clean, smooth lines, an effect which was obtained by the absence of piping on the boiler, except from the sand-box, and the small compact cross-head and guides. The boiler of the "Belpaire" type, the flues being 15 ft. 1 in. long, and the grate area 55.5 sq. ft., the largest of any passenger engine

exhibited. It carries 205 lbs. pressure, which in the 22x26-in. cylinders with 80-in. drivers gives a tractive force of 25,800 lbs. This is the largest of any of the simple passenger locomotives that were exhibited, and is only exceeded by the compounds when they are working simple.

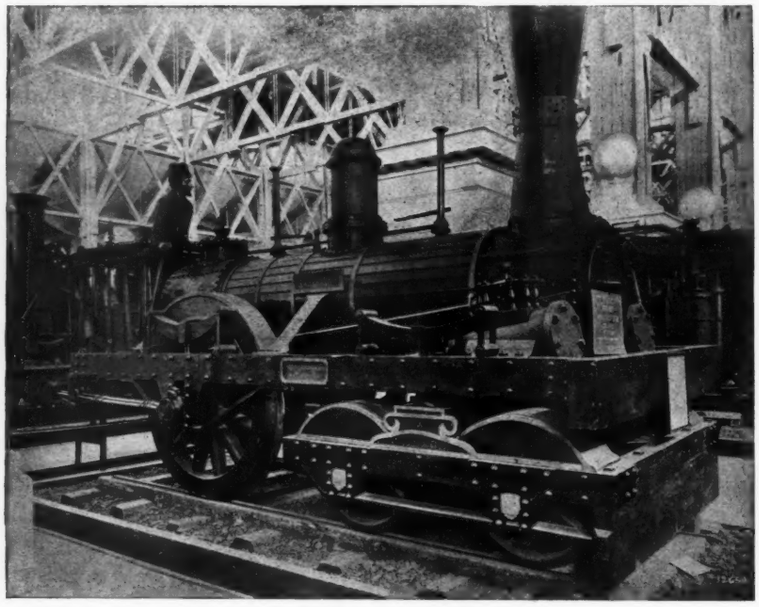


FIGURE 42. "SANDUSKY," FIRST WEST OF OHIO RIVER, ROGERS, 1837

Steam is controlled by balanced slide valves and there is a double bar frame around the cylinders.

In constructional features there are no surprising departures from standard practice.

The climax of the B. & O. historical collection was the Mallet articulated duplex compound locomotive (shown in Figure 59) which in many ways was the most noted exhibit in the Transportation Building. This was the largest and heaviest locomotive on exhibition and the most powerful in the world. It was built by the American Locomotive Company, and is designed for use in heavy pushing service on mountain grades.

The Mallet system of compounding is used for steam and power distribution and consists in introducing two separate engines under the same boiler. The high-pressure cylinders are applied to the rear truck and the low-pressure cylinders to the forward truck. Each pair of cylinders is connected with three pairs of driving-wheels, the rear high-pressure group being rigidly attached to the boiler, while the forward or low-pressure group is on a swiveling frame, the motion of which about its center is duly restrained by springs which also tend to bring the forward group of wheels into proper alignment when the engine enters a tangent. The wheel base of each group of three pairs of driving-wheels is 10 feet, and the total wheel base of the engine is 30 feet 8 inches. The total weight of the engine in working order is 334,500 pounds, or slightly over 10,900 pounds per running foot of wheel base. This is also the weight on the drivers as the locomotive has no front or trailing trucks. The normal tractive power when running compound is over 71,000 lbs., but this can be increased (by working the engine simple) to 85,000 lbs.

Steam-pipes from the dome are led down the outside of the boiler to the high-pressure steam-chests. The steam, which is at 235 lbs. pressure (the highest used by any locomotive exhibited), after being expanded in the high-pressure cylinders, is exhausted into a receiver located between the high-pressure cylinders and thence led by a pipe (fitted with swivel and expansion joints) to the cylinder-saddle of the forward or low-pressure engine, the cylinders of which exhaust (through a swivel pipe connection) to the smoke-box, as usual.

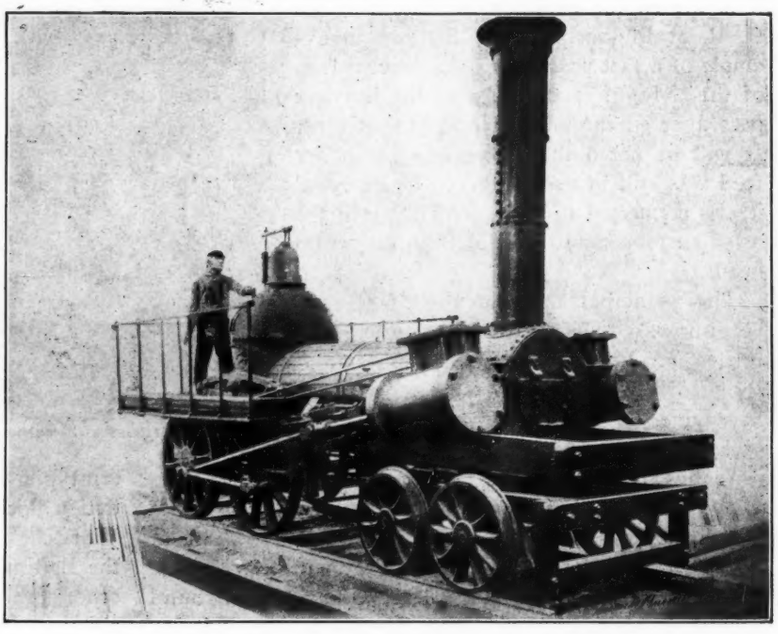


FIGURE 43. "HERCULES," FIRST WITH EQUALIZERS, EASTWICK AND HARRISON, 1837

The high-pressure engine has piston-valves, the low-pressure engine has slide-valves. Both are fitted with the Walschaert outside valve-gear. The reserve lever is arranged to be operated either by hand or by compressed air, as preferred. The high-pressure cylinders are provided with intercepting, reducing, and high-pressure ex-

haust-valves, permitting the use of live steam (at reduced pressure) in the low-pressure cylinders when circumstances require.

This engine can be operated on curves of twenty degrees and upward with great ease and with less frictional resistence than an ordinary consolidation engine of half its capacity. Although it is undoubtedly the largest and most powerful locomotive in the world at the present time, many of its parts are lighter than in many ordinary heavy engines.

At the close of the exposition the locomotive was put in service on the Connellsville division of the Baltimore & Ohio Railroad to assist heavy trains over the mountains. The locomotive was designed for the purpose of balancing the power on the division, and to reduce the number of locomotives and crews required to handle heavy freight tonnage over the mountain districts. The total weight, which is all carried on the 57-in. driving-wheels, as already mentioned, is 334,500 lbs. When the locomotive is in working order, including the tender, which has a capacity of 15 tons of coal and 7,000 gals. of water, the total weight is 479,500 lbs., or about 193,000 lbs. less than the combined weight of two of the heaviest consolidation locomotives that are used for through freight service over the same district.

While the draw-bar pull behind the tender of two of the consolidation locomotives is about 79,400 lbs., the draw-bar pull of the Mallet engine has proved to be about 74,000 lbs. when working compound, and 84,000 lbs. when working simple. The weight of trains that can be taken up the mountain by two of the consolidation locomotives is 2,025 tons, contained in steel cars of about 100,000 lbs. capacity. The weight of train that the Mallet engine and one of the consolidation locomotives can take up the grade is about 3,210 tons, contained in similar cars. These figures are based on the locomotives operating at a speed of ten miles per hour under fair coal and weather conditions, and with the Mallet working in compound gear.

From the results of the practical performance that has been given during the past five or six months, it has been demonstrated that the various special features which are combined in the design of this engine will give satisfactory results from an operating standpoint.

Before passing to a brief mention of some of the more interesting of the other modern locomotives exhibited at St. Louis, it is interesting to notice Figure 60, which shows the monster Mallet compound in comparison with Stephenson's "Rocket," the winner of the English Rainhill trials in 1829. When we look at these two locomotives, each famous in its day, we can realize that there has been a remarkable and enormous development during but seventy-five years of locomotive building.

In addition to the three modern locomotives exhibited by the Baltimore & Ohio Railroad which have just been described, there were shown at St. Louis twenty-seven other modern standard-gauge engines. To describe the interesting construction details of these locomotives would alone take up a full evening, but mention of a few of the more important engines will be made so as to round out a more complete account of the St. Louis locomotive exhibits.

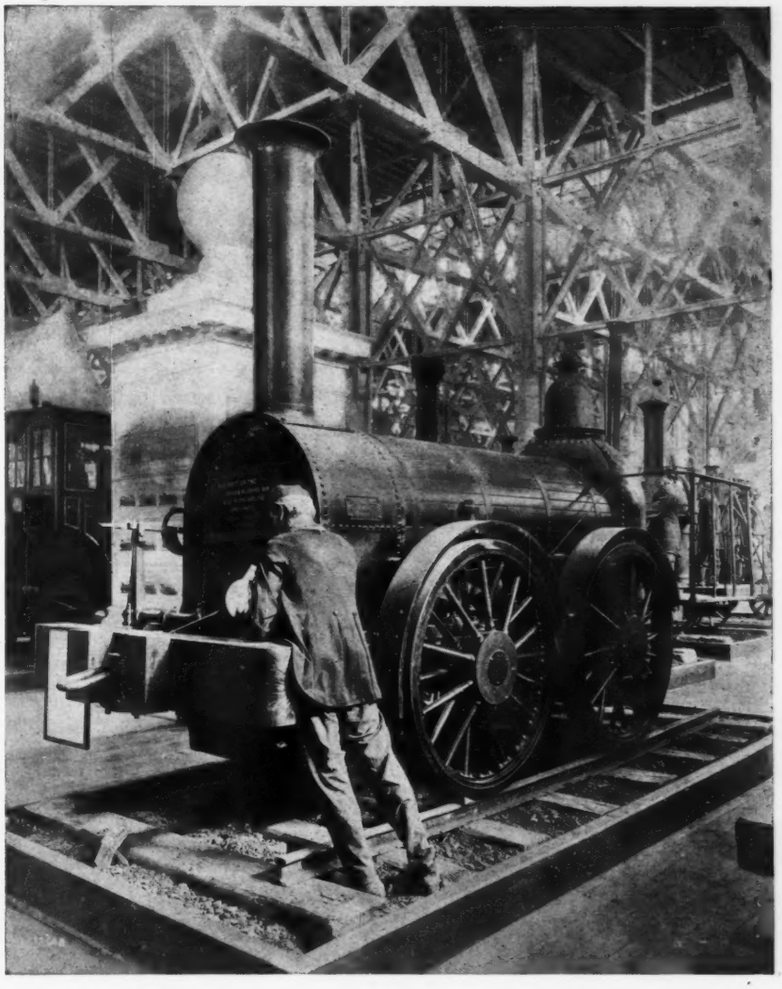


FIGURE 44. "ROCKET," FIRST ON PHILADELPHIA AND READING RAILROAD, BRAITHEWAITE, 1888

Figure 61 shows a tandem-compound locomotive built for the Atchison, Topeka & Santa Fe Railway by the Baldwin Locomotive Works. This locomotive, which in many respects was the representative freight engine exhibited, is of a new type of wheel arrangement in American railway practice, now known as the Santa Fe type. In order to distribute the large weight necessary to make available the power in the 19 and 32-in. tandem cylinders it was necessary to have five pairs of drivers, and two

pairs of single trucks were put in more for the purpose of guiding the engine when running in either direction than for carrying weight. The method of compounding consists in placing both cylinders outside the frame, one ahead of the other and both working on the same crosshead. Two distinct valves, of the piston type, are necessary, both being on the same stem and having the same movement. The steam distribution is practically the same in both. This engine has a weight of 234,850 lbs. on the 57-in. drivers, and a total weight of 287,240 lbs.

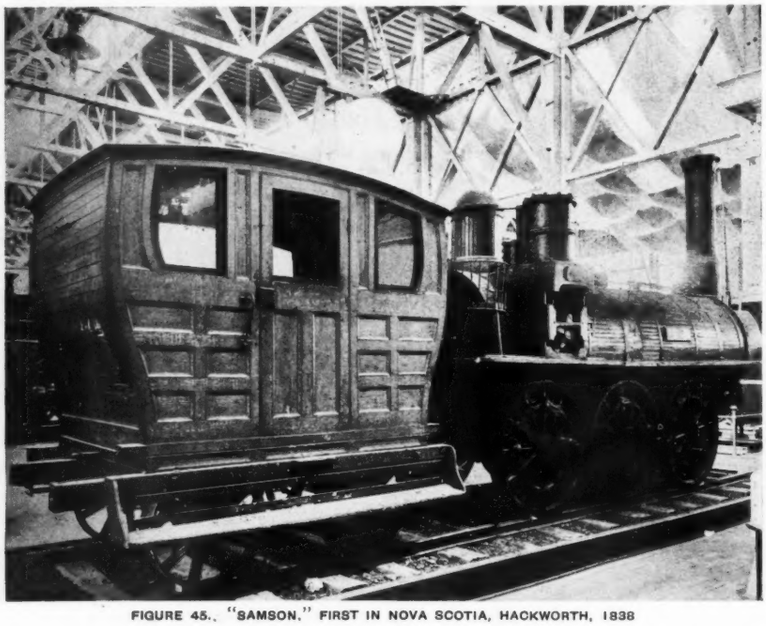


FIGURE 45. "SAMSON," FIRST IN NOVA SCOTIA, HACKWORTH, 1838

In Figure 62 is shown a four-cylinder balanced compound. Atlantic type, passenger locomotive, also built for the Santa Fe R. R. by the Baldwin Locomotive Works. The system of compounding used on this locomotive was the most simple of any of the four-cylinder balanced compounds on exhibition. This design was the pioneer of the balanced engines in this country, and there are at present a large number of the type in successful operation. In construction the locomotive is very simple. Its total weight is 193,760 lbs., 101,420 lbs. of which is on the 78-in. driving-wheels.

Figure 63 shows a simple consolidation-type locomotive built for the New York Central & Hudson River Railroad by the American Locomotive Works. This was the largest of the nine consolidation locomotives on exhibition and is representative of the modern freight locomotive which is now coming into general use throughout the country. The engine weighs 219,000 lbs. in working order and 196,000 lbs. on the drivers. Its tractive power is 45,700 lbs.

The locomotive shown in Figure 64 is a four-cylinder balanced compound Atlantic type, also built for the New York Central by the American Locomotive Works. This was the largest and heaviest Atlantic type locomotive on exhibition, weighing an even 100 tons, with 55 tons on the drivers. Its peculiar appearance due to the location of the high-pressure cylinders attracted to it much popular attention and the methods used in applying the balanced compound principle caused much critical attention from mechanical men during the exposition period.

This design is merely an adaptation of the De Glehn compound of France. The cylinders are located in the same horizontal plane, one ahead of the other, one inside driving a front cranked axle and one outside driving the rear wheel. In this case the high-pressure is inside and the low-pressure outside.

In the matter of construction this engine offers but little out of the ordinary except in the matter of cylinders and their connection. It is an excellent example of modern passenger locomotive designed on lines that have been tried and found satisfactory for the service intended.

One feature is the elimination of excess weights in the driving wheels to counterbalance reciprocating parts, resulting in the elimination of destructive hammer blows on the track.

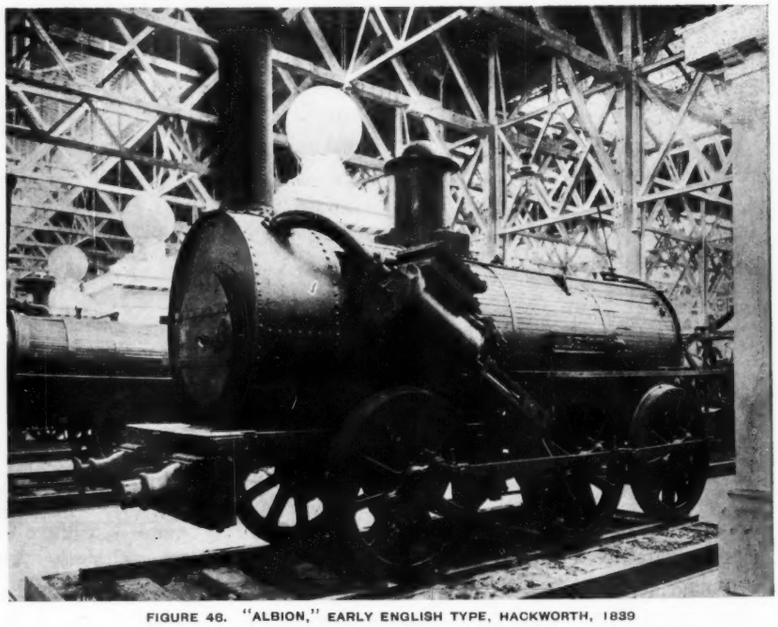


FIGURE 46. "ALBION," EARLY ENGLISH TYPE, HACKWORTH, 1839

Figure 65 shows the most noteworthy of the foreign locomotives exhibited and in some respects the most interesting of all the locomotives at St. Louis

(Concluded in the next issue.)

THE STEAM TURBINE.

THERE have probably been more articles written on the subject of the steam turbine during the last two years than on any other subject dealing with prime-movers, and there is still much more that will be forthcoming.

The advent of the steam turbine into America has been a remarkable one when one considers that only three or four years ago the number of installations could, perhaps, have been counted on one hand, while at the commencement of 1906 every reasonable sized town has one or more in operation, to say nothing of the installations laid down in out-of-the-way places, such as parts of the Dakotas and Indian Territory.

The steam turbine cannot, therefore, be termed an experiment; when one considers the position it holds in the large power stations both in America and Europe, the term would hardly apply. It is in this respect all the more remarkable that an engine so simple in its essentials should so soon take such an important place among the most economical types of compound Corliss engines, the result of many years of thought and experience.

It is the present intention of the writer to give a short history of the turbine, a description of the most prominent types in the service in America to-day, and to make a few remarks as to the durabilities and economies.

The steam turbine was, curiously enough, the earliest form of engine of which we have any record. In the second century B. C., there is mention made of a reaction steam turbine in Hero's book on "Pneumatics." Briefly, the engine consisted of a hollow sphere with two hollow arms attached, the whole rotating on two trunnions. The reactive force of the steam in escaping from the elbow pipes cause the sphere to rotate in an opposite direction.

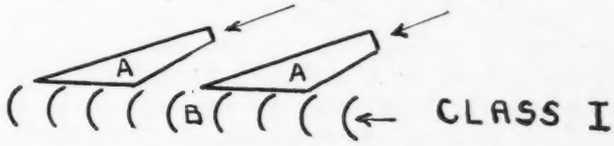
It was not, however, until 1843 that any other turbine is heard of which was of any account. In that year Pilbrow brought out an engine having a turbine wheel, carrying a row of buckets and a steam nozzle through which steam impinged onto the same. As he had not, however, made the discovery of the expanding nozzle whereby he might use his steam expansively, he obtained no reasonable economy.

In 1882 Dr. De Laval, of Stockholm, Sweden, took out a patent for a reaction turbine on the principle of Hero's engine, and the same gentleman shortly after invented his present form of turbine, which is known as the single impulse type.

In 1883 the Hon. Charles Parsons filed two patents in connection with the Parsons turbine, and in 1891 the first Parsons condensing steam turbine was constructed for the Cambridge Electric Supply Company, of Cambridge, England. This engine was tested by Prof. Ewing, and its efficiency proved to be "equal to that of the best reciprocating engines of the same power."

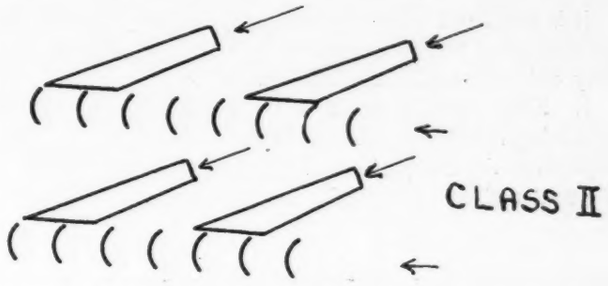
It might be well before going further into the descriptions of the turbines in present use to classify the different types, and in order to do this the following five classes are suggested:

Class I.—The simple impulse class—one stage, in which the steam is fully expanded in the nozzles *AA* by virtue of which the potential energy present in the form of



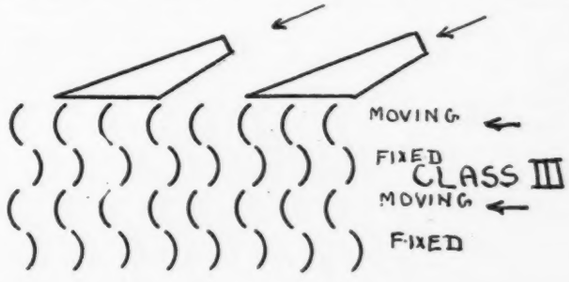
pressure is all converted into velocity or kinetic energy, and the horsepower obtained by its impact with the bucket. It has been shown that the only losses present in this change from pressure to velocity is in the friction in the nozzle and the small heat losses while passing through the same. An example from this class is the De Laval steam turbine.

Class II.—A combination of Class I; where the steam is only partially expanded in the first set of nozzles, and after leaving the blades passes through another set of



nozzles and blades in as many as from twelve to fourteen stages. An example of this class is the Rateau steam turbine, manufactured in Paris, France.

Class III.—Where one set of nozzles is used and several sets of veins or buckets alternately fixed and moving.

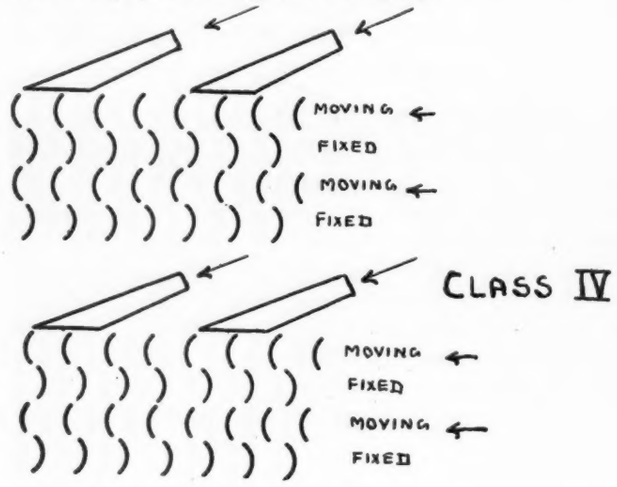


The advantage claimed for this type is the decreased velocity of the blades due to the compounding of the steam. An example of this type is the Stump turbine.

Class IV.—A combination of several sets of Class III; *i. e.*, one set of nozzles in which only partial expansion takes place, a set of veins alternately fixed and moving, and then another set of nozzles and veins, up to four or five stages. An example of this class is the Curtis turbine, manufactured by the General Electric Company.

Class V.—To which could be placed all turbines having no nozzles. The steam entering at boiler pressure through a large quantity of blades or veins alternately fixed and moving expands itself in its passage from blade to blade, each blade taking up a certain amount of kinetic energy from the steam. An example of this class is the Parsons

turbine, and the Westinghouse-Parsons turbine, manufactured by the Westinghouse Company.



It is needless to say there are many claims put forward by the steam turbine engineers, and it is perhaps necessary only to mention the most prominent.

1. Economy of space is the most noticeable, of which a striking illustrative example is shown in Figure 1., and represents the comparison of space occupied by a 5000-kilowatt reciprocating engine set, and a steam turbine of the same capacity.

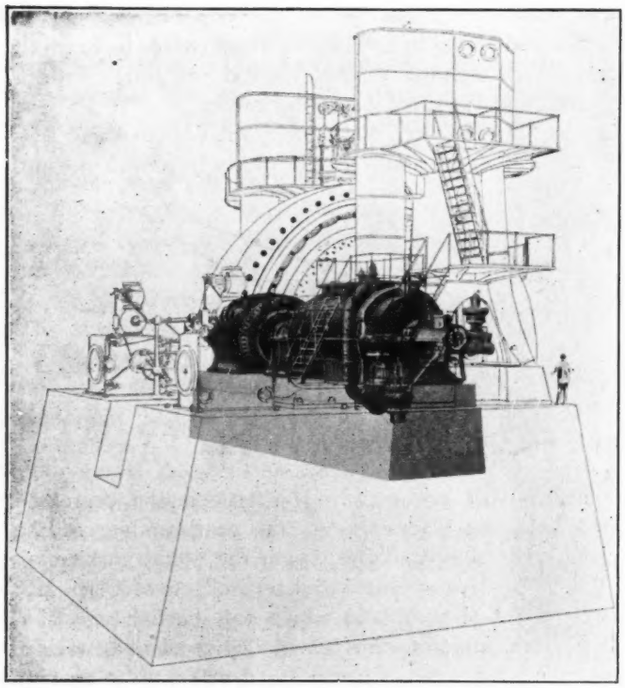


FIGURE 1

2. The decreased cost of foundation. An example coming under the author's notice only a few days ago on a small 120 horsepower unit gave interesting comparisons. In getting out the bids for alternating propositions, it was found necessary to allow $537.60 for the foundation of the reciprocating engine, while the steam turbine came through with $101.35, a difference of $435.25. Naturally in larger units this is of considerable importance.

3. Absence of any cylinder oil and of any oil in the exhaust, and thereby admitting of an installation where steam is used over again from a surface condensing without the trouble of oil in the water.

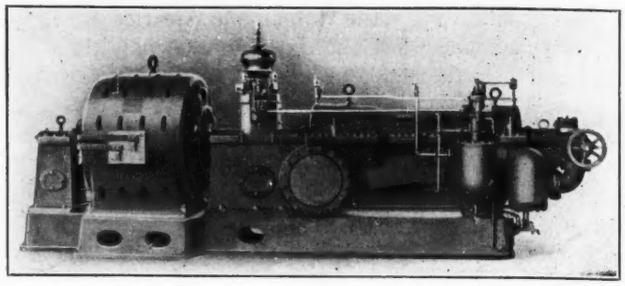


FIGURE 2

4. Cheapness in the first cost and simplicity in design with elimination of all reciprocating motion.

5. Having no oil in contact with the steam, no trouble is due to high super-heat.

6. No danger from serious priming of the boiler.

Many other claims might be mentioned, such as close speed regulation and large capacity for overloads, but the former appealed to the author as being sufficient justification.

The best known types in operation in America at the present day are the Westinghouse, De Laval, and Curtis, as represented in Classes V., I., and IV.

The Westinghouse turbine, which is shown in Figure 2, consists of a turbine "rotor" or rotator, which carries rotating blades. This tapers in its diameter and is smallest at steam admission end, increasing in diameter with larger blades as the steam expands and increases in volume. The blades are inserted in sets and opposite to each set of buckets the rotor carries balancing pistons equal to the number of stages of the rotating blades. Each of these pistons is of such diameter as to just balance the end thrust caused by the reaction of the steam on its way down the rotor. The rotor also carries a series of bearing rings whose sole duty is to maintain an exact relationship between the rotor and stator parts.

The stator, or cylinder, carries all the fixed blades corresponding to the revolving blades on the rotor. An annular compartment at the beginning of the expansion space admits the high pressure steam. There is also a secondary valve for admitting steam directly in the second stage when operating under heavy overloads.

Steam is admitted into the turbine in successive puffs, and governing is performed by a constantly moving pilot valve controlled by a fly-ball governor.

The speed of the Westinghouse turbine is found to be best adaptable to an alternating current. A 400-kilowatt turbine revolves at 3600 revolutions per minute.

The Westinghouse turbine is manufactured in sizes from 600 horsepower to 10,000 horsepower.

The Curtis steam turbine is manufactured by the General Electric Company and is embodied in Figure 3. It

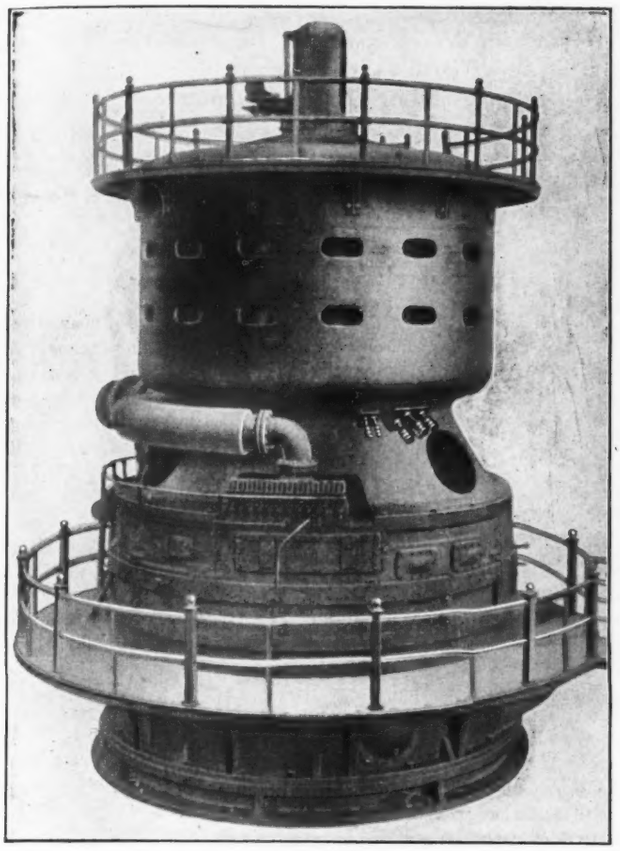


FIGURE 3

is original in its design from the fact of its being a vertical turbine. From the cut it will be seen that the electric generator is carried on top and that the turbine proper is placed directly over the condenser. The entire weight of the revolving parts being taken on a step bearing of special design, which in the majority of cases is supplied with oil at high pressure from an accumulator, and in the smaller units from oil pumps.

The Curtis turbine of the more recent type is designed in four stages and vary in their speed according to the capacity. A 3000 horsepower unit revolves at 900 revolutions per minute.

The governing of the turbine is carried out by a centrifugal governor placed on the top of the machine, and its method of operation is to cut off steam from different sets of nozzles as the load gets lighter and vice versa, thereby diminishing the throttling effect on the steam with beneficial results.

In the earlier types of this machine the valves were operated electrically, but now a purely mechanical device has been gotten out.

The Curtis turbine is manufactured in sizes up to 7500 horsepower, and it is understood that they have now on order a turbine of 10,000 horsepower capacity.

The De Laval turbine belongs to Class I, and has but one set of nozzles and one turbine wheel. Owing to the presence of high speeds in the turbine wheel several interesting applications of mechanical skill have been introduced into the design.

The most prominent feature is the "flexible shaft." It was found that it was impossible to rotate a wheel at such velocity without serious vibration, and the patenting of the flexible shaft by De Laval denoted the entrance of the De Laval turbine into the field. By using this shaft, the wheel is permitted to revolve on its own center of gravity in place of its center of sphere, thereby taking out all vibration. This change in the axis of rotation; *i. e.*, from center of sphere to center of mass, takes place at about one-third the speed, at what is called the critical point.

Figure 4. shows a detailed sectional drawing of a 300 horsepower turbine, and it will be noticed that the turbine wheel *A* is a very heavy section towards its center. This was done to give the wheel ample capacity to withstand the centrifugal strains which are naturally the greater in the inside of the wheel. *B* is the ball bearing which allows of the necessary change of position which the flexible shaft takes up when the engine is running. *C* is the pinion engaging with the gears *DD*, having a ratio of ten to one, and *EE* are the flexible couplings which connect the turbine with the electric generator, or whatever unit the turbine is running in connection with.

The oiling is done by gravitation from a central tank, and after passing to the bottom of the gear case is used over again.

Figure 5 shows a De Laval steam turbine connected to two centrifugal pumps in series, having the capacity of 3300 gallons a minute at 125 feet.

The governor, which is of the centrifugal throttling type, is placed on the slow speed shaft and consists of two semi-circular leaves which on opening out operate through a ball crank on a balanced valve placed in the steam chest. The turbine is equipped with both condensing and non-condensing nozzles, each designed to give the highest efficiency under either condition of working. The gearing for reducing the speed of the turbine wheel from ten to one is of a special helical design and is enclosed in the gear case as shown in Figure 5.

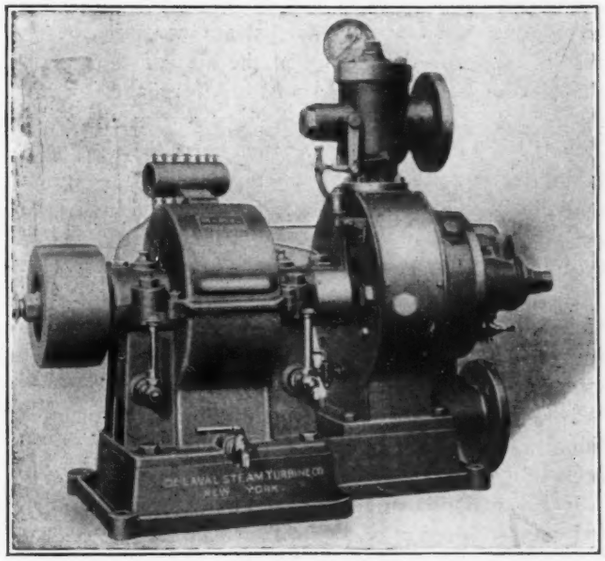


FIGURE 4

The question of durability and economy in speed turbines is without doubt the most important one to the practical man.

It has been claimed, and perhaps rightly, that very little data has been forthcoming as to the wear of buckets, etc., and the resultant depreciation of steam economy. The fact that steam turbines have only been in operation

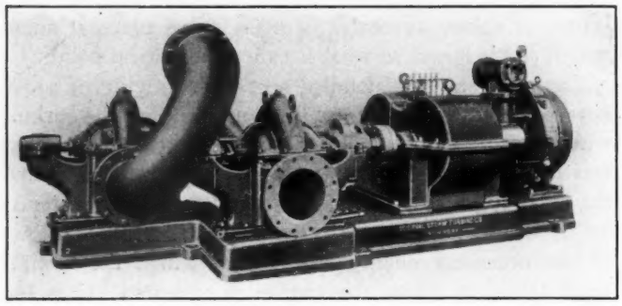


FIGURE 5

for such a comparatively short time is probably the cause for the supposed holding up of the information.

A test that came under the personal observation of the author will be interesting in this respect. It was made on a turbine of 150 horsepower at the New England Structural Company's plant at Boston, Mass., in June, 1905, after having been in continual regular service for two years. The test, which was on nine hours duration and was conducted by Prof. Miller of the Boston Institute of Technology, gave the following results:

Boiler pressure, 152.9 pounds; vacuum in inches, 25.47; average kilowatt, 106.1; brake horsepower, 160.4; steam per E. H. P., 20.05 pounds; Steam per B. H. P., 17.77 pounds; Superheat, nil; moisture in steam, 1.05 per cent.

Note.—The moisture in steam was not taken into consideration in the above figures.

The original guarantees called for 18.7 pounds when operating with steam at 152 pounds, and twenty-six inches vacuum.

Many tests have been run on the large units which have gone to show very fine steam consumptions, the results naturally depending on the size of the unit and the steaming condition. One test of reliability gave a figure of 10.25 pounds for brake horsepower on a Brown-Boveri-Parsons turbine of a capacity of 2600 kilowatts, taking steam at 188 pounds, twenty-seven inches vacuum, and 214 degrees of superheat. It will be seen that these are figures that stand well beside the highest types of triple expansion engines of to-day.

As regards durability, many examples could be furnished of steam turbines working in operation of twenty-four hours a day continuously. The last one coming under the observation of the author being in Seattle, Wash., where a 300 horsepower turbine has been in continual operation for twenty months without ever having been shut down.

In conclusion it might be stated that an important point to be remembered in regard to the steam turbine, it, that it is essentially a constant speed machine and therefore that it would be useless for performing such duties as a direct hoisting engine where the full horsepower is demanded at the start. For this reason it will be seen that the field for the reciprocating engine will always be a big one even if eventually the turbine should leave it behind in the generating station or in such cases where more or less constant speed is called for, such as the driving of centrifugal pumps or air blowers. *Harry Y. Haden.*

THE FOURTH JOVIAN CONGRESS.

THE Fourth Jovian Congress, of the Order of Rejuvenated Sons of Jove, the only fraternal organization of those engaged in the advancement of the science of electricity, was held at Dallas, Texas, October 14, 1905, at which time the following officers were unanimously elected for the ensuing year:

Jupiter, C. A. Newning, No. 2, Houston, Tex.; Neptune, L. G. Reed, No. 200, Sandusky, O.; Pluto, W. M. Brooke, No. 18, Dallas, Tex.; Vulcan, J. H. LaRoche, No. 183, Cohoes, N. Y.; Mercury, C. B. Roulet, No. 213, Dallas, Tex.; Hercules, P. R. Boole, No. 183, Chicago, Ill.; Mars, F. C. R. Spence, No. 67, Marshall, Tex.; Apollo, J. P. Tufts, No. 71, Dallas, Tex.; Avrenim, W. G. Handley, No. 152, Cincinnati, O.

The Order of Rejuvenated Sons of Jove was born among the leading spirits of the Southwestern Gas, Electrical and Street Railway Association at an annual convention held at Austin, Tex., in 1899. Since that time it has grown with a rapidity astonishing to its founders, who were men from many states and holding responsible offices in the electrical world, although to date its meetings have been confined to the annual Association gatherings in the Southwest and in Ohio.

The foundation of the Jovian Order was inspired to bring devotees of the science of electricity and its allied interests into closer communication and membership, to the end that information and learning might be more general and effectively diffused; that love and pride of profession might be installed in every heart; brotherly feeling engendered, and that ties and links be forged at the Anvil of Vulcan, which shall lengthen until it shall encircle the globe, thus cementing its members in a common bond of good fellowship.

Of the Ritual nothing can be written. To enjoy its beauties and understand its lessons, it will be necessary to approach the Shrine of Jupiter, and to become a Rejuvenated Son of Jove.

It is the intention of the present Jovian Congress to hold Rejuvenations at the next annual conventions of the National Electric Light Association, The National Electrical Contractors Association, the National Electrical Jobbers Association, and the Southwestern Electrical and Gas Association, at which time candidates are requested to present themselves for Rejuvenation.

Mythological basis, application blanks and constitution and by-laws of the order may be secured by addressing the office of Mercury, C. B. Roulet, Wilson Building, Dallas, Texas.

STEAM TURBINES AS RESERVE POWER IN WATER TRANSMISSION SYSTEMS.

The Missouri River Power Transmission Company, operating in the vicinity of Helena, Mont., and notable as being one of the highest voltage transmissions in the world, has begun the erection of a steam turbine power plant to operate as a reserve to their present water power plant. A large part of the output of the Missouri River system is transmitted to the city of Butte and the Anaconda district mining properties, and the service has grown to such an extent as to warrant the erection of a reserve plant as a protection against serious fluctuations in the available water power.

FRED E. SANDER, PRESIDENT, SEATTLE-EVERETT INTERURBAN RAILWAY COMPANY

SEATTLE-EVERETT INTERURBAN RAILWAY.

TO attempt to chronicle events connected with the electrical industries of the Pacific Northwest, particularly Seattle, Wash., and its environs, without referring to the man who has been one of the dominent factors in its up building and present prosperity, would be to tell but a part of the story. Fred E. Sander, president of the Seattle-Everett Interurban Railway, came to Seattle in March, 1880, and found a town of some 3500 population, growing it is true, but giving no promise at that time of becoming the magnificent city of 180,000 that it is today.

Mr. Sander with characteristic perspicacity foresaw the future of this hustling little community, and plunging into the business life of the place with persistent energy was soon recognized as one of the prominent elements in Seattle commerical affairs.

In 1887 he organized a company and built the Yesler Avenue Cable Line, the first cable road on the Pacific Coast north of San Francisco. The venture opened up the way to Lake Washington and was a financial success almost from the commencement of operation. About this time he also built the first electric light plant.

Two years later came the great fire, entailing losses to the business interests of Seattle aggregating $10,000,000, and while faint hearts and pessimists were droning a doleful requiem over the ashes of the fire scourged city, determined men, among them Fred E. Sander, were planning a new and greater Seattle, and the city stands today a glorious monument to their unflinching faith. With this new, substantial growth, a population of 50,000, constantly increasing, came a natural demand for civic expansion and modern means of transportation, and among the enterprises of this kind launched were the Grant Street Electric Railway and the Washington Electric Company, both of which were promoted, financed and built by Mr. Sander.

With his mind ever on the alert for business openings, he became largely interested in real estate and invested heavily in shipping, realizing that Seattle's geographical location and magnificent harbor would one day make her an important factor in Oriental trade.

During the next few years Mr. Sander promoted and built the James Street Cable Road, the Union Trunk Line and the Front Street Cable Line. One by one he sold his interests in these various railway and lighting plants, and they were absorbed and consolidated gradually into the one large company which now operates the entire system and is controlled by the Stone-Webster Company, of Boston, Mass.

As it is ever the case where two important commercial centers are in close proximity to each other, Seattle and Tacoma, thirty eight miles apart, were filled with pardonable civic pride and natural civic jealousy, and when Mr. Sander first conceived the idea of an interurban railway connecting the two communities he was met with violent opposition, enthusiastic supporters of both cities vehemently argued that "no good thing could come out of Nazereth" and "Nazereth" was always at the other end of the line.

Opposition but whetted the keen edge of his ambition and by pure force of his powerful personality and his deep rooted faith in the ultimate success of the undertaking he organized and built the Seattle-Tacoma Interurban Railway, and today its stock and bonds are selling far above par, and from the start it has exceeded the expectations of its promoters and builders and Fred E. Sanders judgement was again vindicated. This road has also been absorbed by the Stone-Webster syndicate.

Meantime a modest little settlement had been located on Puget Sound thirty-two miles north of Seattle, and very shortly began to thrive on daily doses of a vigorous western brand of commercial nourishment, and took unto itself the name of Everett. Unknown in 1890, Everett has today a population of approximately 40,000, with numerous manufacturing industries and all the modern attributes which go to make up an important commercial center.

In the territory laying between Seattle and Everett and comprising its greatest immediate wealth are magnificent forests of

GRADE THIS SIDE BITTER LAKE SEATTLE-EVERETT INTERURBAN RAILWAY COMPANY

GREENWOOD STATION, SEATTLE CITY LIMITS, SEATTLE-EVERETT INTERURBAN RAILWAY COMPANY

fir and cedar trees. This timber is in the hands of a few owners who only waited for transportation facilities to market the same. To meet this condition Mr. Sander organized the Seattle-Everett Interurban Railway Company, and this enterprise bids fair to become the crowning achievement of twenty years active participation in the promotion and construction of local and interurban street railways in the Northwest. The company is capitalized at $1,750,000, and has an authorized bonded indebtedness of $2,000,000, five per cent., thirty years, first mortgage gold bonds, of which $1,500,000 are to be sold and $500,000 to remain in the treasury for future developments. The officials of the Seattle Everett Interurban Railway are Fred E. Sander, president; N. B. Sander, vice-president; and G. W. Albin, secretary and treasurer.

The general course of this line from Seattle lies northward, passing through the town of Ballard and touching Edmunds and Richmond Beach, the total length of the line to Everett being thirty-two miles, with five turn-outs, and using sixty pound steel rails. The preliminary surveys show a maximum grade of two and one-half per cent. at one point, and when completed it is

LOGS ON RIGHT OF WAY, SEATTLE-EVERETT INTERURBAN RAILWAY COMPANY

LEAVING CITY LIMITS GOING NORTH, SEATTLE-EVERETT INTERURBAN RAILWAY COMPANY

calculated to make the run between the terminal points in one and one-half hours, including stops. Seven miles of the line have been completed, and the company are at present operating two passenger cars and twenty freight cars, the latter being hauled by a 200 horsepower General Electric Company's electric locomotive.

Five miles of grading has been finished in addition to the completed line, and it is estimated that the entire road will be ready for operation by August 10, 1906. The present plan is to build and equip the road first-class in every way and rent power from one of the electric power company's until it is thought best to develop the companies own power at Gold Bar, where it is stated that they own a waterfall that will generate 10,000 horsepower. This water power is twenty-two miles from the line.

Mr. Sander states that the seven miles in operation is more than paying its operating expenses, the passenger traffic even for this short distance has been heavy and the company have a number of important log hauling contracts, among which is a contract with the Lake McAleer Mill for hauling their entire output, one with W. A. Piper for 40,000 feet per day and a recent order to deliver 6000 cords of wood in Seattle.

This road is but another exemplification of the importance of interurban railways in the development of the entire country and the bringing of now segregated communities into quick touch with commercial centers, and that Seattle and Everett and the intervening points will reap a rich benefit from the operation of this road is beyond a question.

THE ELECTRICAL SHOW AT THE COLISEUM.

THE success of the electrical show announced for January at the Coliseum is already assured by the fact that more than one-half of the available floor space for exhibition purposes is sold and the firms which have contracted for this space are the largest and most representative ones in the electrical trade. Many new and wonderful inventions will be shown and there will be innumerable novelties in the way of appliances and apparatus to interest visitors. "College Row" is to be a feature. Three thousand square feet is allotted to the schools and colleges of the middle west having technical departments, and each school will display every day some novel tests and demonstrations. "College Row" will be unique in decorations, the emblems and colors of the various colleges to be the feature along these lines. This department of the electrical show will be in charge of Dr. Henry Crew, professor of physics at Northwestern University, Clarence E. Freeman, professor of electrical engineering at Armour Institute, Charles H. Smith, editor of *School Science and Mathematics*, Professor R. A. Milliken, of the University of Chicago and Professor P. B. Woodworth, head of the technical department of Lewis Institute. During the exposition there will be several conventions in Chicago including the Northwestern Electrical Association and the Electrical Salesmen's Association.

The 200th anniversary of the birth of Benjamin Franklin, philosopher, scientist and statesman, will be more fittingly and elaborately observed in Chicago than in any other city in the United States, not excepting Boston or Philadelphia, the former his birth place and the latter the home of his achievements. Franklin was born January 17, 1705. By a coincidence, the electrical show, which promises to be the greatest of the kind ever held in the world, will be on at the Coliseum. President Insull and the directors of the exposition plan to make Wednesday, January 17, "Franklin Day," special and appropriate features to be arranged for that occasion. Franklin's scientific investigations of 150 years ago were the foundation for the wonders of today in electricity, consequently nothing could be more appropriate then a great modern electrical exposition of the observances of his birthday. The Philosophical Society, of Philadelphia, of which Franklin was one of the founders and which is still extant, will be invited to participate, and the technical schools of departments of the colleges in the West will probably be asked to take part in the program. It has been suggested that the representatives of the Trades hold a banquet on the evening of "Franklin Day" at which everything served will have been cooked by electricity.

Director E. H. Overshiner, of the exposition, is in communication with Senator Hopkins with the hope that the latter will get the Government to establish a wireless telegraph station at the show which will be under the direction of Rear Admiral Manney, of the Bureau of Equipment, and from which the Government tests will be continued. It is the desire of the directors to make long distance records by the wireless, both for direct and relay messages,

It is announced that several notable and interesting men will attend the exposition, including Thomas A. Edison, the wizard of Menlo Park, his son, De Forest, of wireless telegraph fame, and many others whose interest in the success of electricity has made them great figures in the technical world.

The electrical exposition will be made particularly interesting to the housewife. One firm is going to exhibit a complete electrical kitchen, including the stoves, the pots and pans and boilers and broilers, and the chafing-dish, with a guarantee of no dust, no smoke. There will be electric machines for house cleaning, machinery for washing dishes, roasting and grinding coffee, chopping meat, kneading dough, doing the laundry work, cleaning metal effects, polishing silver and jewelry, cooling the refrigerator, pressing clothes, rocking the baby, heating the bottle of milk, the curling iron and the heating pad for the sick room; in fact, there will be no end of interesting things in the show.

A few of the many prominent concerns that will have an exhibit are the American Steel and Wire Company, Crocker-Wheeler Company, Monarch Electric and Wire Company, Universal Electric Storage Battery Company, Quarantee Electric Company, Mark Manufacturing Company, J. L. Schureman Co., H. E. Cobb, Roth Bros. & Company, Geo. W. Conover, Sweedish-American Telephone Company, Oliver Manufacturing Company, Reynolds-Dull Flasher Company, Western Electric Company, American Electric Company, Sprague Electric Company, Haller Machine Company, Vesta Accumulator Company, Electric Appliance Company, J. Lang Electric Co., I. A. Bennett, Crane Company, Osburn Flexible Conduit Company, Krantz Manufacturing Company, Electric Storage Battery Company, Chicago Battery Company, Chicago Edison Company, Chicago Pneumatic Tool Company, Electric Dynamic, Safety Armorite Conduit Company, Federal Electro Company, Safety Insulator Wire and Cable Company, Overbagh and Ayers Manufacturing Company, General Electric Company, Peru Electric Manufacturing Company, Ft. Wayne Electric Company, H. Y. Paiste Company, W. H. Schott, Samuel J. Gorman & Co., Vim Company, C. H. Thordarson, Telephony Publishing Company, Central Electric Company, Automatic Electric Company, Miller Anchor Company.

PERSONAL.

Mr. W. L. Goodwin, of the Jno. M. Klein Company, has returned from an extended trip throughout the East.

Mr. Geo. W. Tapping, formally of Point Richmond, has been appointed general superintendent of the Oxnard Light and Water Company, Oxnard, Cal.

Mr. Howard Aylsworth, of the Kilbourne & Clark Co., left for the East December 23d, stopping en route at Los Angeles for the Christmas holidays. He expects to be away a month or six weeks.

Mr. Wallace W. Briggs, manager of the San Francisco office of the Westinghouse Electric and Manufacturing Company, who has just returned from a trip East, reports a most gratifying condition of business at the home office, where an unprecedented rush of orders has kept the entire force working overtime. The outlook for 1906 is particularly bright, special activity being shown in single phase motors.

IN MEMORIAM.

William Henry Edgar, president and founder of the Dearborn Drug and Chemical Works; born November 25, 1865; died November 26, 1905.

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VOLUME XVI JANUARY, 1906 NUMBER 1

EDITORIAL.

THE VANCOUVER POWER COMPANY.

The electrical plant of the Vancouver Power Company, a complete description of which is begun in this issue, is unique among all of the many electric power transmission systems of the Pacific Coast. Not only is the plant one of the largest yet constructed, but the character of the installation is in many respects entirely different from other plants which have been constructed during the past ten years.

The entire hydraulic development consists of tunnels and large natural lakes for reservoirs. No flumes or ditches, or in fact any work of a temporary character has been done on the entire system. While the first cost of such construction is large, the maintenance charges and depreciation are thereby reduced to a minimum. The life of such a plant is, of course, long, and it is reasonable to suppose that no changes will be required for years to come.

It is questionable whether any hydraulic development has ever been made in connection with an electric power transmission system which guarantees continuous operation to the extent possible with the plant of the Vancouver Power Company. Not only is the water conduit system such that there can be practically no interruption, but in addition there is at the head of the pipe line a large natural storage, which makes it possible to carry high peak loads, a feature which is found to be most desirable in the operation of such plants.

The entire installation, including the generating station and the four substations, with the machinery which has been installed, go to make up a well co-ordinate plant. In its entirety the different portions of the plant have been adapted to work most effectively in conjunction with the complete installation. This was made possible by having the whole installation under the control of practically one man during the preparation of the plans and also for the entire period of construction.

The stockholders aud directors of the company are principally London men. For this reason particular care was taken during the period of construction to make complete monthly reports of the progress of the work, as well as the monthly expenditures. The most accurate indication of the progress of such work is shown by photographs, and the illustrations in connection with the article, show how thoroughly such photographs served to render the monthly progress reports of value, It is certainly worthy of note that the rate of progress of the work as well as the result of money expended were shown monthly to the officers of the company.

Experience has shown that in general large power systems have been built to meet the requirements of communities requiring all the available power which can be developed immediately upon the completion of the plant. In this case, however, confidence has been shown by the directors in the future development of Vancouver and vicinity. The total population which can be depended upon to utilize the power here developed is not great. The possibilities, however, for future demand were considered such, by those interested, as to justify the building of a complete transmission system of sufficient size and capacity to meet the demand not only at the present time, but for years in the future.

For certain purposes the comparatively temporary character of the work done on the Pacific Coast may be preferable. In the end, however, such installations as that of the Vancouver Power Company, cannot but be the best, not only from an engineering, but also from a commercial standpoint.

UNCLE SAM WORKS MAGIC IN THE NORTHWEST.

CLARENCE J. Blanchard, of the United States reclamation service, arrived in Minneapolis recently after a summer spent in the west looking after federal irrigation interests.

"A remarkable transformation is taking place in many of the most forbidding sections of our inland desert empire," said Mr. Blanchard. "Oases are springing up like magic in many places which for ages have been the abode of the coyote and the jack-rabbit. A year ago last spring I slept out under the sagebrush on the Minidoka lands in the Snake River Valley, Idaho, and the nearest dwelling was thirty miles away.

"Last week I visited the same spot, travelling across that thirty miles in a first class psssenger train, passing through three new towns. On every eighty acres of the 10,000 acres in that tract of Government land there is a new farm house, a farmer and his family. Uncle Sam is preparing to bring to him through many miles of canals and ditches the precious water which is to make the desert blossom as the rose. A mammoth rock-fill dam across the Snake River is almost finished and by early spring the sagebrush will have vanished from this spot forever."

Early next April Uncle Sam will try his hand at auctioneering and to the highest bidder will dispose of some very choice lots, business and residence, on three new townsites under this project. In anticipation of this sale more than eighty business firms have put up temporary structures and are doing business there. The indications are that there will be a city of not less than 5000 inhabitants under this project. By the time the water is ready for the land, there will be a farm population of nearly ten thousand located on these lands.

An effort will be made this winter to secure the necessary Congressional action to permit the Government to use the proceeds of these sales for the construction of sewer and water works systems, and other municipal improvements for the new towns, the money to be repaid in the same manner that the settler repays the cost of the irrigation works. This is not a new departure for the Government, as the reclamation service engineers under the direction of the Secretary of the Interior for some time have been expending several hundred thousand dollars in building bridges, water works, sewerage systems, school houses, etc., in Oklahoma, the money having been obtained from the sale of town lots.

SPECIAL EVENING LECTURES.

SPECIAL evening lectures will be given by the Department of Electrical Engineering of the University of Washington during 1905-96 on the following subjects:

"Electric Traction," by Elbert G. Allen, M. S. (Mass. Inst. of Tech.), chief electrical engineer, Seattle Electric Company.

December 4—"Traction Dynamics."

December 11—"Train Movement."

December 18—"Generating and Substations for Electric Railways."

January 8—"Power Distribution for Electric Railways."

January 15—"Railway Economics."

"Central Station Practice," by J. D. Ross, chief electrical engineer, Seattle Municipal Electric Light and Power System.

February 5—"Central Station Organization, Management and Records."

February 12—"Switchboards."

February 19—"Metering."

February 26—"Arc Lighting."

March 5—"Tests, Repairs and Trouble Work."

"Electric Power Transmission," by John Harisberger, chief electrical engineer Seattle-Tacoma Power Company.

April 30—"Source of Power."

May 7—"Prime Movers."

May 14—"Apparatus for Generating Electric Power."

May 21—"The Transmission Line."

May 28—"The Receiving Stations and Distributing Lines."

These lectures are part of the regular courses given during the year on "Electric Railways," "Electric Lighting" and "Power Transmission," and will be included in the field covered by the semester examinations.

While the lectures are primarily intended for members of classes in the above mentioned courses, the discussion of each topic will be sufficiently complete to be of value and interest to other students and particularly to the practical man in the electrical field. The treatment of each subject will be eminently from a practical point of view; the statements made and conclusions reached will be in accord with, and largely the results of, the lecturer's personal experiences.

Desiring to give the electrical men in Seattle, Tacoma and vicinity an opportunity to hear these lecturers, the department of electrical engineering extends a cordial invitation to all men interested in the topics discussed to attend, whether or not they are connected with the University. The lectures are all free of charge, but prompt attendance is requested, so the work may proceed without interruption.

RURAL TELEPHONE GROWTH.

THE farmers of Waitsburg have decided to enlarge their telephone system. An additional night operator will be placed in the central office and the switchboard capacity increased five times. The changes are necessary to meet the demands on the company for more telephones in the homes of farmers. According to the *Waitsburg Times* there are more than 200 rural telephones in operation at present. They are distributed over twenty lines centering in that city. It is now proposed to reach every prominent farmer in sections tributary to the trading center.

A rural telephone is considered one of the necessities for the farmers of today. It enables him to transact business at home and keep in touch with the city merchants. It saves the expense of driving to the city every time something is wanted. One wagon can carry parcels for a dozen or more families along a line. The articles may be ordered by telephone. Every farmer in the wheat and barley producing district has credit at all places in the city. He can buy what he wants and mail a check for the bill at any time. To him there are joys in living on the farm.

The creamery industry has increased the demand for telephones. Many of the farmers are engaging in extensive soil culture. They own a few cows and cultivate some land to diversified crops. The hay and roots of the farm are fed to dairy cows and the milk sent to the city creameries. Every month the dairy check adds to the bank account and brings more independence to the farmer. With the rural mail added to the rural telephone there is little necessity for the industrious farmer to waste time in visiting the cities.

There are future possibilities for the community that increases its rural organizations. One expert in dairying can do more than a dozen inexperienced men. One telephone may save many dollars in the transaction of daily business affairs. It expedites matters in the calling of physicians and neighbors in cases of sickness or fire. It helps every form of local organization and increases the spirit of neighborly friendship. It removes much of the loneliness of the farm far away from the railroad or busy city. As a financial proposition it is a good dividend payer and an addition to the value of every community.

TYPICAL AMERICAN HOSPITALITY.

"We are to have the honor of entertaining the members of the American Society of Mechanical Engineers during the December meeting of the society in New York.

"The morning session of Wednesday, December 6th, will be held on the S. S. "Amerika" with an early adjournment to permit the members and guests to take a special train leaving the Hoboken station of the D. L. and W. R. R. at 12:45 p. m., for our new works at Harrison, N. J.

"Upon arrival at the works a light luncheon will be served, after which a thorough inspection of the plant will be made. The special return train will leave our works at 4:45 p. m.

"We believe you will feel amply repaid for the time spent in inspecting the plant, which embodies the experience of sixty years in building hydraulic machinery and was designed and equipped with the view of making it the finest possible for its line of work.

"We extend a cordial invitation to you personally and trust your engagements will permit of an acceptance and allow us to number you among our guests."

HENRY R. WORTHINGTON.

New York, November 15, 1905.

BOOK REVIEW.

Instruction Book No. 3019—Fort Wayne Electric Works, Inc., Fort Wayne, Ind. Containing general description, ratings and general dimensions, also complete instructions for the installation, operation and maintenance of the single phase "Wood" alternating current generators manufactured by this company.

High Tension Power Transmission—A series of papers and discussions presented at the meetings of the American Institute of Electrical Engineers, under the auspices of the committee on high tension transmission. Four hundred and sixty-six pages. Republished by the McGraw Publishing Company. Price $3.00. A book of the highest value to all engineers interested in the above subject. It contains introductory articles on various topics related to the above subject with extended discussions. The report of the committee of the American Institute includes a collection of authentic data furnished by forty-seven companies engaged in transmission work, furnishing a fund of reliable information that could have been collected in no other way.

"Follow the Wires."—A bulletin issued by the Denver Gas and Electric Company is one of the neatest advertising books we have ever seen. Every gas and electric company on the Coast should send for one.

The Sibley Journal of Engineering, Cornell University, Volume XX, No. 1—Is filled with most excellent articles by Walter Rantenstrauch, A. G. Rakestraw, Professor V. Dorelshauvers, Dory and H. B. Foote.

For California—The November number of *For California*, published by the California Promotion Committee, is devoted to the forest and lumbering industry of the State of California, and is one of the best numbers issued by the committee.

Catalogue No 16—Recently distributed by the Phoenix Glass Company, of Pittsburg, New York and Chicago, is a handsome book 14½ x 12 inches in size containing forty pages, seventeen of which are full page plates, illustrating the electric globes and shades manufactured by the company.

"The Transit"—Published by the Engineering Society of the University of Iowa; price 50 cents. A limited edition of 1000 copies of this very valuable book has been issued. It contains many interesting articles by able writers and numerous tables that are of great assistance to the engineer.

Clarkson Bulletin No. 4, Volume II, October, 1905—The Thomas S. Clarkson Memorial School of Technology have just issued a very neat book containing articles from William S. Hedrick, M. E., director of the above named school. Walter S. Graffarn, B. S., Myra Brewston Clark, A. B., A. M., Homer M. Derr, A. M., Ph. D., and Chas. H. Lawrence.

Proceedings of the American Institute of Electrical Engineers, Volume XXIV, No. II, for November—Is a very interesting and beautifully illustrated number. It contains a very able paper, by N. J. Neall on "Performance of Lighting Arresters on Transmission Lines." American Institute of Electrical Engineers, office 95 Liberty Street New York. Price 50 cents.

Westinghouse Circular No. 1108—Issued by the Westinghouse Electric and Manufacturing Company explains in detail the regulating reversing controllers manufactured by that company. Each type of controller is carefully described and illustrated for the benefit of prospective users. Controllers are shown as actually in use in various establishments including the plants of the Lucas Machine Tool Company, the Le Blond Machine Tool Company and others.

Hornsby Akroyd Oil Engines.—The De La Vergne Machine Company, of New York, is sending out to its trade an illustrated folder in the interest of the Hornsby Akroyd oil engines. One of the most important application of these engines is in isolated lighting plants, such as United States Light Houses, Light Ships and Fortifications, where hundreds are now in use, and in private residences, but they are also being extensively used in pumping and general power plants.

Bulletin No. 41—California Mines and Minerals—Issued by the California State Mining Bureau. Complied by Chas. G. Yale, Statistician State Mining Bureau. This Bulletin is one of the numerous publications provided by the State Mining Bureau covering in detail the conditions existing in California in all various branches of mining. The bureau publishes an annual Statistical Bulletin and the figures and tables given in Bulletin No. 41 are taken from this annual with the evident intention of giving a clear and concise idea as to the mineral resources of the State and what the miners are accomplishing.

Synchronous and Other Multiple Telegraphs—Some methods of obtaining independent telegraph circuits on a single wire both with and without sychronism, by Albert Cushing Crehore, Ph. D. One hundred and twenty-four pages; illustrated. McGraw Publishing Company, New York. Price $2.00. An exposition of much valuable work that has been carried on for some years by Professor Crehore, fragmentary accounts of which have from time to time appeared in the columns of the technical press. A book of great importance, and the methods outlined are destined to have great influence in determining the future development of telegraphic work. The book is not burdened with ancient history, but is full of live present day interest.

Electricity Versus Steam for Train Haulage.—A thirty-eight page booklet form the offices of the General Electric Company at Schenectady, N. Y., contains two interesting papers, one by W. B. Potter, on "Developments in Electric Traction," which was read before the New York Railroad Club last January and the other by L. R. Pommeroy on "The Electrification of Trunk Lines." Both papers are profusely illustrated and provided with tables and digrams, showing a comparison of the results obtained from the use of electricity with those obtained from the use of steam in general train haulage. The papers take up in detail the experiments of the New York Central Railroad with a locomotive designed and built by the General Electric Company and the American Locomotive Company. This new publication seems to speak the last word on the subject of "Electricity Versus Steam for Train Haulage."

TRADE CATALOGUES.

Catalogue No. 700—"Steam Engine"—The Westinghouse Machine Company's catalogue is a neat book of thirty-six pages descriptive and illustrative of their standard engine generating set and standard engine.

The Bossert Electric Construction Company, Utica, N. Y., are sending out their new catalogue on Plugged Steel Conduit Boxes, Monitor Conduit Bushing, Erickson Conduit Insulators, Flexible Conduit Bushings, Armored Conductor Bushing.

Catalogue No. 128.—The Allis-Chalmers Company, of Milwaukee, Wis., last catalogue is on "Crushing Rolls" for crushing ores of all descriptions, rock, coal and salt. It contains fifty-six pages of valuable information to the miner. Mailed free upon application.

A neat catalogue has just been issued by the G. W. Price Pump Company containing very interesting matter on all styles of pumps together with a number of valuable tables and instructions on setting up and operating same. Yours for the asking. Address the G. W. Price Pump Company, 523 Market Street, San Francisco.

Fort Wayne Electric Works, Inc., have just issued several very valuable works. Instruction book No. 3022, on Induction Motors; Bulletin No. 1071, on Small Power Motors; Bulletin No. 1072, on Wood System Single Phase Motors; Bulletin No. 1074, on Wood Systems Multiphase Induction Integrating Type K, Wattmeters.

Circular No. 1124—Westinghouse Electric and Manufacturing Company—The No. 121 direct current motor recently placed upon the market by this company is designed for the same class of suburban and interurban railway service as the No. 76 and No. 85 motors. Circular No. 1124 illustrates and describes the No. 121 motor and can be obtained by addressing any of the Westinghouse offices.

Bulletin No. 3—Electric Storage Batteries of the "Unit Accumulator" type for Car Lighting—National Battery Company, Buffalo, N. Y. Covering the salient points of this company's output of batteries for car lighting. It is stated that the claims made for these batteries are very conservative and the company earnestly solicit a thorough investigation. This company call attention to the "National Sparkers" for gas motors and "National Batteries" for electric vehicles in an attractive little leaffet which briefly and clearly details their claims for this apparatus.

Portland General Electric Company's Bulletin for November, is another attractive and artistic advertisement of what the merchant can do with lighting signs. The halftones are works of art in that line and it shows a very careful study of the subject. The Portland General Electric Company may well be proud of the good work they are doing. The bulletin also contains many illustrations of interior lighting and many little inexpensive electrical conveniences for the home.

National Electric Company, Milwaukee, Wis.—Bulletin No. 330, "Water Wheel Type Alternating Current Generators" and Bulletin No. 358, "Belt Driven Alternating Current Generators." The National Company make many broad claims for their apparatus and careful perusal of these bulletins seems to substantiate their statements. The National Company's advertising literature may be procured by addressing their recently established Pacific Coast sales office, 530 Rialto Building, San Francisco, Cal.

Allis-Chalmers Publications—

Catalogue No. 127—"Sampling Plants and Equipment"—Describing and illustrating typical sampling plants of various capacities, and machinery built for the equipment of such plants. This publication will be mailed on application by interested parties.

Bulletin No. 1405—"Portable Rock Crushing Plants"—Descriptive of the different types of portable plants representing a few of the many built by this company. An application will bring copies of this bulletin and catalogues describing the Gates breakers and crushing plant accessories.

Bulletin No. 1406—"Forged Steel Balls for Ball Mills"—Enlarging upon the use of forged steel balls in mills for dry crushing, a process heretofore practiced much more extensively abroad than in this country, but it is stated that they are now coming into favor for a great variety of uses. This publication will be mailed on application by interested parties.

Bulletin No. 1407"—The Bennetts Pouring Spoon"—Claimed as one of the latest improvements in accessories for converting stands, effectually preventing a large amount of the splash and spatter of copper and practically eliminating all of the labor usually required to gather the copper thus spattered in pouring. It is stated that the Bennetts spoon is furnished with all of the Allis-Chalmers converters. This publication will be mailed on application by interested parties.

Bulletin No. 409—Switchboards for Small Direct Current Plants—Stanley G. I. Electric Manufacturing Company, Pittsfield, Mass.—It is stated in this Bulletin that this line of switchboards has been designed to meet the requirements of the customer operating an isolated plant with a single generator and any number of feeder circuits from one to six, inclusive. This Bulletin and discounts from the list prices given therein will be furnished on application to the district offices of the Stanley G. I. Company.

Turbines—Trump Manufacturing Company, Springfield, Ohio—Describing a complete and comprehensive line of turbines manufactured by this company. The extensive development of water power in the West necessarily increases the general interest in turbines, and judging from the illustrations and descriptive matter in the above mentioned catalogue the Trump Company have kept well up to date with their product. The West Coast Machinery Company, 525 Mission Street, San Francisco, are the Pacific Coast agents for the Trump Manufacturing Company.

Standard Telephone Apparatus and Standard Wiring Diagrams—De Veau Telephone Manufacturing Company, New York.—This company manufacture an extensive line of telephone apparatus of all kinds and their catalogue in addition to portraying the various devices and parts of same includes a complete set of wiring diagrams. It is stated that they make a specialty of Marine telephones and switchboards for vessels of every description, also for diving purposes. The Standard Electrical Works, 120-130 New Montgomery Street, San Francisco, represent the De Veau Company on the Coast and requests for catalogues or information regarding this product will be promptly furnished.

Dixons Index—For Pencil Users—The messenger boy who digs a smudgy stub out of his pocket for you to sign for a telegram with, the bank president making a memorandum of a million dollar transaction, the artist rapidly sketching his ideas and the editor mercilessly "blue pencilling" your copy are all interested, conciously or unconciously, in lead pencils, and the Joseph Dixon Crucible Company, Jersey City, N. J., have thoroughly emphasized this in their index, a booklet of thirty-two pages covering pencils for every class of work and including an interesting description of the method of manufacture of their product. The Dixon Company say "If you have not found the pencil that is just right for your work, consult the Index." The booklet may be had on application to the home office or any of their agencies.

The Otis Elevator Company's New Catalogue.—The great elevator industry of the Otis Elevator Company was founded in the year 1854, over half a century ago, by E. G. Otis. Starting in a small shop at Yonkers, N. Y., the business has since grown and expanded, and the original factory has developed into the great industrial establishment illustrated in the book. With the development of the business, it has from time to time become necessary to build factories in other cities and in other counties, and, in some instances, to acquire existing establishments devoted to this branch of manufacturing. With each increase of facilities it has been possible to further improve the product. The present corporate name of "Otis Elevator Company" was adopted in 1898, and in this catalogue is presented an outline of the various types of elevators and hoisting machinery manufactured by them.

General Electric Company's Publications—

Addenda, to accompany Supply Catalogue 7521—GE 57--A Railway Motor Brush Holder Barrel Spring Type.

Flyer No. 2168. Incandescent Lamp Socket for Out Door Decoration.

Luminous Electric Radiator. The cuts in this little booklet show a very ornamental appliance for which is claimed efficiency in operating expense and inexpensiveness in first cost, also safety and cleanliness.

Edison Lamps. Illustrating the General Electric Company's large and varied output of incandescent lamps.

Flyer No. 2167. Plng Cut Outs for 125 and 250 volts.

"Mercury Arc Rectifiers," by P. D. Wagoner. Reprint of papers read before the National Electric Light Association at its Twenty-eighth Convention, Denver-Colorado Springs, Colo.

Supply Catalogue, No. 7591. Parts of Edgewise Parallel Rod 110 Volt Direct Current Multiple Enclosed Arc Lamp, Forms fourteen and twelve.

Bulletin No. 4421. Descriptive and Illustrative of the GE 80 Railway Motor.

Bulletin No. 4422. Portable Substations for Electric Railways. A very interesting development in substation practice which should win the attention of street railway managers.

Curtis Steam Turbine. Describing and illustrating some of the larger and more important turbine installations of the General Electric Company.

Supply Catalogue No. 7593. Parts of Form three, Twin Carbon, 220 volt, Direct Current Multiple Enclosed Arc Lamp.

The above publications may be had by addressing the General Electric Company, Schnectady, N. Y., or any of their branch offices.

New Doble Water Wheel Catalogue.—The first comprehensive catalogue describing the "Doble Tangential Water Wheels," distributed by the Abner Doble Company, of San Francisco, has

just been issued. The publication which is known as the company's Bulletin No. 7 treats the subject in a concise and detailed manner.

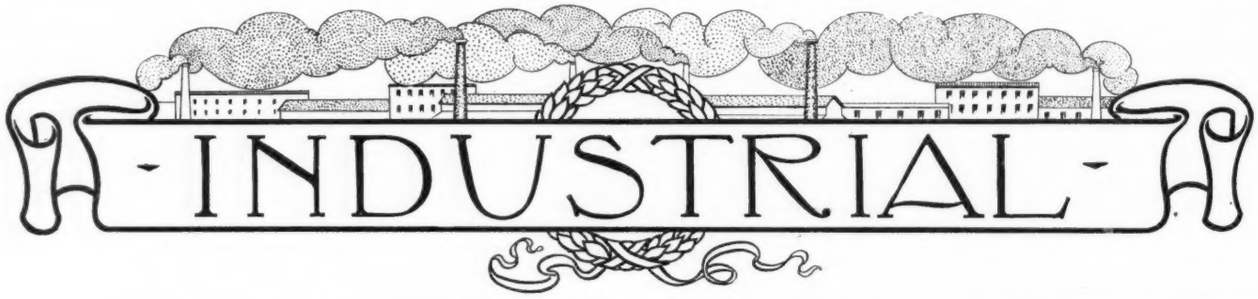
The first portion of the catalogue contains general matter descriptive of the essential features and parts entering into the construction of Doble tangential water wheels, special attention being paid to the Doble needle regulating nozzles, ellipsoidal buckets, ring-oiling bearings, nickle-steel shafts, etc. Illustrations of several different types of water wheels are followed by descriptions of some of the typical hydro-electric power plants in which Doble water wheels are operating.

Of particular interest are the large hydro-electric units described, special mention being made of the 8000 horsepower wheels installed in the de Sabla and Electra power house and the 9000 horsepower wheel now being built for de Sabla. The descriptions of Mill Creek No. 3 and Cornell power plants are of interest by reason of the high head of the former and the efficiency tests obtained from the Cornell wheels. These latter tests show an efficiency at full load of 84.5 per cent.

The latter portion of the book contains the Doble water wheel tables, covering all conditions of water power up to a head of 2550 feet, and in capacities up to 5000 horsepower. Other tables relate to the loss of head in pipe by friction, riveted steel pipe, etc., and four pages contain useful hydraulic information. The last seven pages are devoted to a series of ready conversion factors, most of which have been compiled from a recent work by Carl Hering.

The catalogue shows that considerable conscientious time and effort has been spent in its preparation, and a commendable feature is that no extravagant claims are made for the products described. The descriptions of the power plants have been carefully prepared and contain much valuable information, considerable of which has never heretofore been published. The engineering tables and hydraulic data make the catalogue a valuable engineering reference book, the data being represented in such readable and convenient form that the book is sure to be retained by an engineer for reference purposes.

The catalogue is of the standard six inches by nine inches size and contains 100 pages. The press and typographical work are of the best, the half-tone illustrations being especially clear. The whole is neatly bound in a soft brown cover suitably embossed.



PACIFIC ENGINEERING COMPANY.

ORGANIZED in September, 1904, the Pacific Engineering Company have in the intervening time built up for themselves a splendid reputation as engineers, contractors and representatives of a standard line of engineering supplies.

The officials are technical men of well known ability. C. D. Lamont, M. E., president, is a graduate in mechanical engineering, Cornell University, and in his business career has been connected with some of the largest concerns in the country, among them being the Cramps Ship and Engine Building Company, the Union Iron Works, Moran Bros. & Co., the White Pass and Yukon Route and is an ex-superintending engineer of the Pacific Coast Steamship Company at Seattle. Mr. Lamont is a member of the Pacific Northwest Society of Engineers and the National Association of Stationary Engineers.

J. P. Badenhausen, M. E., secretary and treasurer, is a graduate in mechanical engineering, Stevens Institute, and a post graduate in the same course, Cornell University, and is also a member of the National Association of Stationary Engineers.

Mr. Badenhausen has been connected in an engineering capacity with the American, Morgan and Atlas steamship companies, the New York Shipbuilding Company and the Tietjen and Lang Dry Goods Company.

An inspection of the Pacific Engineering Company offices, sales rooms and warehouse, corner of Washington Street and Railroad Avenue, Seattle, Wash., is prima facia evidence that they have exercised a high order of skill and judgment in the selection of their agencies.

The Jeffrey Manufacturing Company, Columbus, O., was established in 1878, and their output of chain belting, steel cable, elevating and conveying machinery, electric locomotives, etc., is too well known to require any entended comment. The Pacific Engineering Company are the Northwestern agents for the Jeffrey Company and are prepared to submit specifications, plans and estimates for the equipment of complete plants with the Jeffrey product and will be pleased to mail any of the numerous publications issued by them.

The Mason Regulator Company, Boston, Mass., manufacturers of reducing valves, pump governors, pressure regulators, boiler feed pumps, automobile engines, etc., state that their product represents the accumulated experience of nearly a quarter of a century devoted to the building of these appliances, and in their catalogue they make a well founded claim that "it is not what you pay for an article, but what the article pays you in return for what you paid for it that determines its value to you." A large stock of Mason appliances are carried in Seattle, assuring immediate delivery.

The Ashton Valve Company, Boston, Mass., are so well established in the engineering world that it is almost superfluous to itemize their product. The Ashton pop safety and relief valves and pressure and vacuum gages are a standard the country over and the Ashton company's newly revised catalogue, No. 12, brings very clearly to notice the meritorious features of these goods by its concise detailed information fully illustrated by valuable cuts. Their well known specialties represented and fully stocked by the company are the Bowers Rubber Company, San Francisco, Cal., manufacturers of a complete line of mechanical rubber goods; the Crandall Packing Company, Palmyra, N. Y., Crandall's improved steam, ammonia and hydraulic packing; the D. T. Williams Valve Company, Cincinnati, O., manufacturers of the Williams re-grinding valve.

The Pacific Engineering Company also represent the Geo. E. Dow Pumping Engine Company, San Francisco, Cal., the largest Coast manufacturers of hydraulic machinery.

The Lane and Bodley Engine Company, Cincinnati, O., builders of the well known Corliss engines of the same name.

A. A. Griffin Iron Company, Jersey City, N. J., manufacturing heaters, radiators and "Bundy" specialties.

The Pacific Engineering Company, manufacture locally a large line of special iron goods, heaters, separators, exhaust heads, etc., and with this line of high grade agencies, a complete and comprehensive stock and their personal engineering ability they should exert a powerful influence in the advancement of the Northwest commercial and engineering interests.

A NOVEL WATER HOIST.

THE question of unwatering a mine always is a serious problem to the mine management, especially so when the water is highly impregnated with acids. When the amount becomes excessive the means to be employed for disposing of it taxes the ingenuity of all concerned to the uttermost.

In the anthracite regions there are mines in which for every ton of coal raised as high as fourteen tons of water must be pumped, and the latter must be done at a minimum of expense. Nowhere, probably, have a greater variety of pumps and lifting devices been tried, and the most satisfactory type, up to date, for handling large quantities of water at comparatively low heads, have proved to be large bailers operated by steam engines. These, however, lack the mechanical regularity inherent in a pump, as they are necessarily operated by men, and it remained for The Delaware, Lackawanna and Western Railroad Company and its electrical engineer, H. M. Warren, to finally develop a water-hoisting equipment which would preserve all the valuable points of the steam hoist and at the same time operate automatically.

The carrying out of the mechanical details of the hoist and its automatic devices were confided to the Wellman-Seaver-Morgan Company, of Cleveland, O. Most of the electrical controlling devices were furnished by the Electric Controller and Supply Company, Cleveland, O. In the original specifications The Delaware, Lackawanna and Western Railway Company called for the hoist to be operated by an alternating current motor of 800 horsepower, and the question of starting, stopping and reversing so large a motor had, at the outset, to be met. The duty to be performed by the hoist called for the raising of 4000 gallons of water per minute to a height of 550 feet.

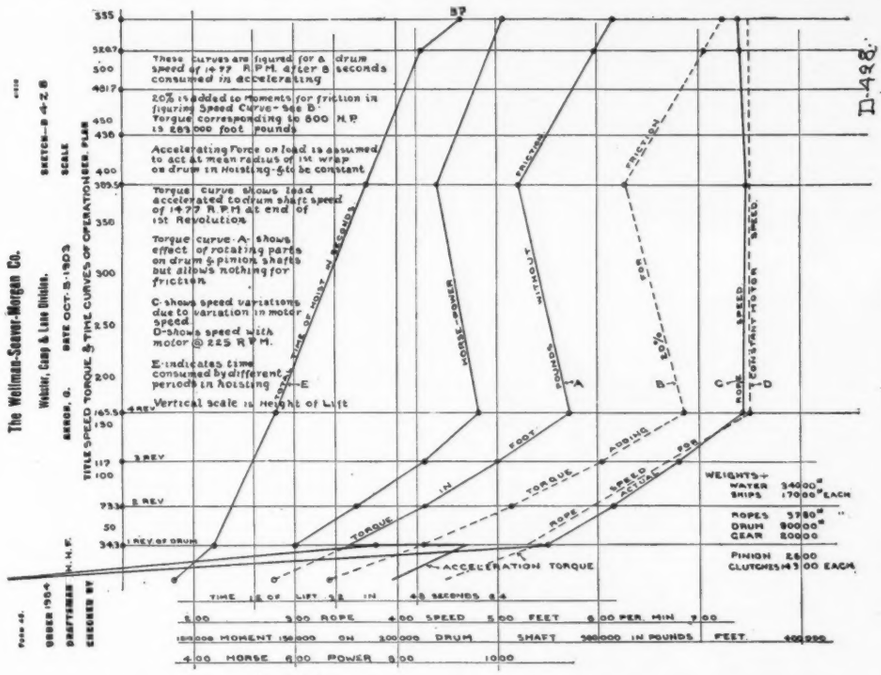
4000 gallons $\times$ 8.27 = 33180 pounds.

500 feet two-inch rope $\times$ 6.3 = 3465 pounds to be raised 550 feet per minute.

$$\frac{36645 \times 550}{33{,}000} = 610 \text{ net horsepower.}$$

Weight of bucket equals one-half weight of water, so that weight on rope equals 53,235 pounds or nearly twenty-seven tons, requiring two-inch steel rope. The various preliminary speed and movement diagrams are laid out per accompanying diagram.

It was decided in carrying out the design that it would be impracticable to design the hoist other than have a motor running continuously in one direction, as it is a well known fact that the amount of current required to accelerate a large motor of this type is enormous, and greatly interferes with the proper running of the power plant.



The Delaware, Lackawanna and Western Railroad Company desired to use an alternating current motor directly at the hoist, and as the motor was to run continuously in one direction, this necessitated the use of friction clutches for accelerating and reversing the load.

Figures 1 and 2 show a front and side view of the hoist. As will be noticed the general arrangement consists of a motor driving a pair of bevel wheels through a single bevel pinion. The bevel wheels run loose on a shaft and are fitted with the well known Webster, Camp and Lane friction clutches. The operating mechanisms for the clutches are so designed that only one clutch can be thrown in at a time, but both clutches can be out at the same time. Throwing in one clutch runs the drum in one direction; throwing in the other clutch reverses the motion of the drum.

To the shaft on which the bevel wheels run there is keyed a pinion meshing with main gear on the drum shaft. The drums are of the cylindro-conical type, ten feet at the small diameter and sixteen feet at the large diameter. At a hoisting speed of 550 feet per minute the drum makes about fifteen revolutions per minute. There is one main brake located between the drums. All of the clutches and brakes are operated by auxiliary air cylinders fitted with oil cushion cylinders, the compressed air being furnished by a motor driven air compressor and the necessary

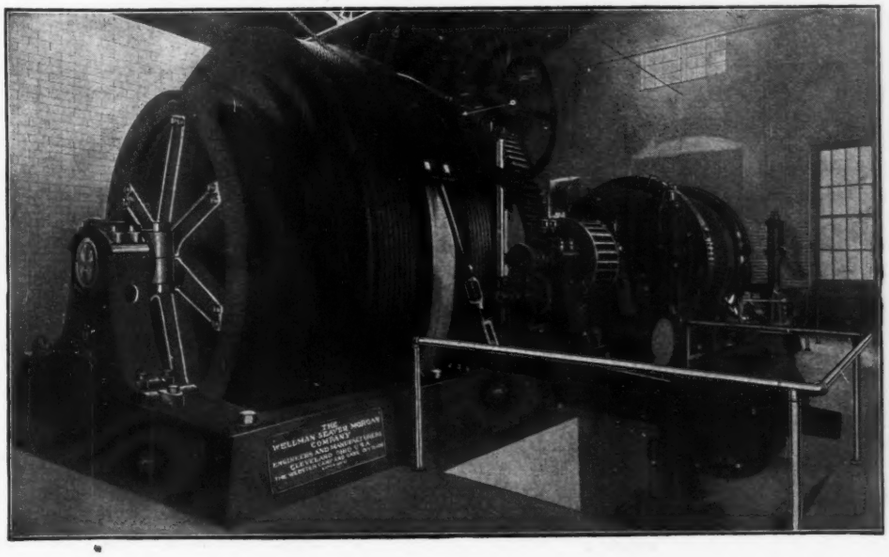


FIGURE 1

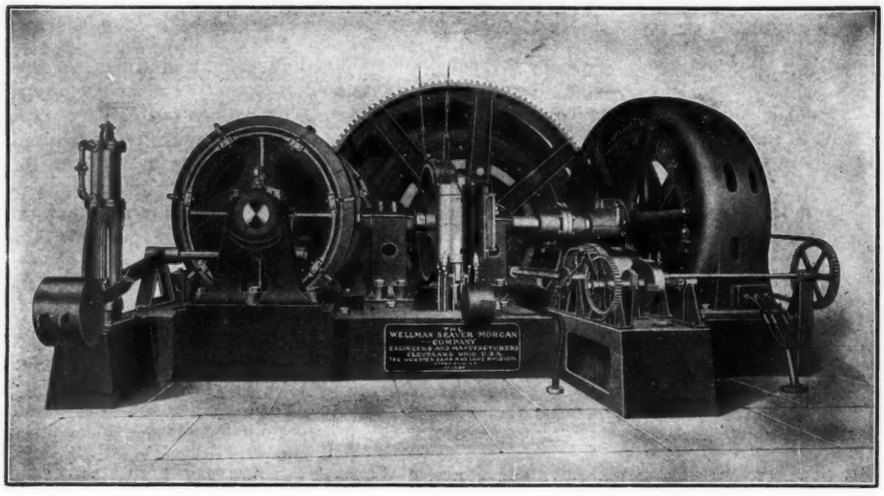


FIGURE 2

tanks located near to the hoist. The hoist is controlled by a mechanical device shown in Figure 2. This device consists mainly of a drum rotated by means of a friction drive from the motor through a sprocket chain. The drum shaft transmits its motion to a secondary shaft fitted with variable speed which in turn operates a secondary stop. The main hoisting drum shaft operates a traveling nut which is so located with respect to the controller drum that at either end of its travel it releases a stop and allows the controller drum to make a quarter turn. This movement, through suitable electrical connections, operates the solenoids on the clutch valve, releasing the clutch and the solenoid on the brake valve setting the brake, the further movement of the controlling drum being arrested by the secondary stop. This stop is released by the variable speed shaft and its connections, which has been given a predetermined time movement corresponding to the interval for emptying the bucket. The further movement of the controlling drum releases the brake and throws in the reversing clutch, thus starting the hoist in the opposite direction, and also starting the traveling nut on the controlling mechanism in the opposite direction. At the end of the hoist the cycle of controlling movements is repeated, and so on, making the hoisting operation continuous and automatic. Every attention has been given to the safe operation of the hoist. The main brake is of the gravity type, and to be released the current must be on the solenoid operating the valve so that air can be admitted to the under side of the brake piston.

If for any reason either the supply of current or of air pressure is interrupted, the valve drops, and the weights on brake lever set the brake.

FIGURE 3

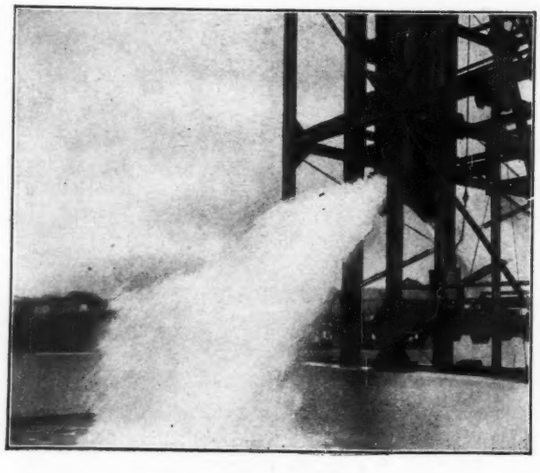
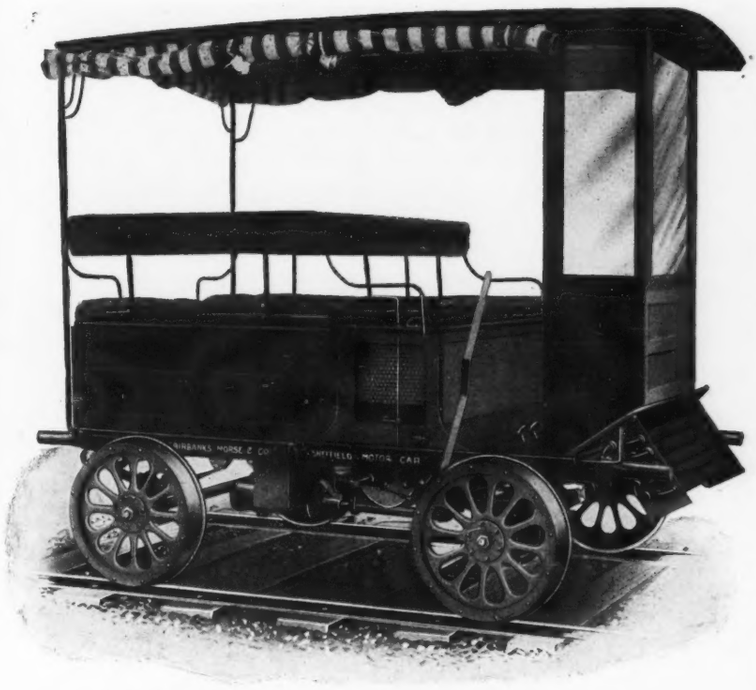


FIGURE 4

The clutches are designed so that they are thrown out by weights. As is the case with the brake, either clutch can only be thrown in when the current is on the solenoid, and the air pressure admitted under the piston, and if either current or pressure fail, the clutch is off. The motor shaft is fitted with an emergency brake operated by a weight controlled by a solenoid; any interruption in the flow of current to the motor sets the brake and stops the motor. Any interruption of the flow of the current stops the machine, throws out the clutches and puts on the brake. A safety cut-out is provided for in the head frame so that in case a bucket is carried beyond the proper height the current is cut off.

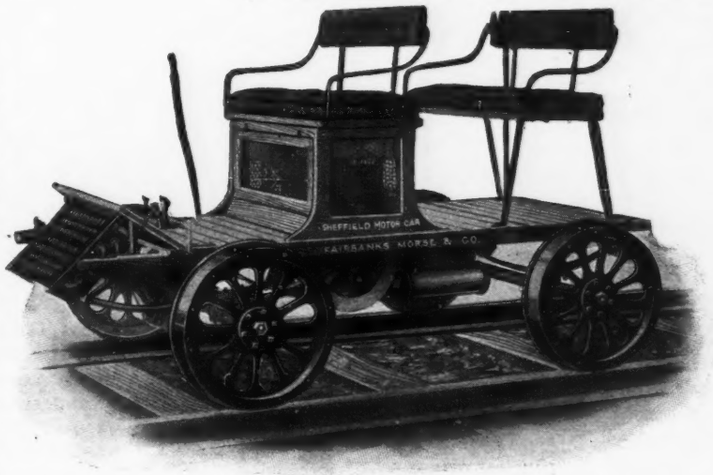
Figure 3 shows the head frame. The head frame is ninety-three feet from the base to the center of the sheave at the top. It is built of structural steel, roughly, in the shape of an "A." From the head frame are suspended two buckets six feet in diameter and nineteen feet six inches deep. The capacity of each bucket is seventeen tons of water. In the bottom of the bucket are located two lift gates with an area practically equal to the cross-section of the bucket. These gates are lifted automatically when the bucket reaches the top, and the water is discharged through the bottom into a spout fitted below the bucket, and which deflects it to either side of the shaft. Each bucket makes a complete round trip in one minute and fifty seconds, the total lift being 555 feet.

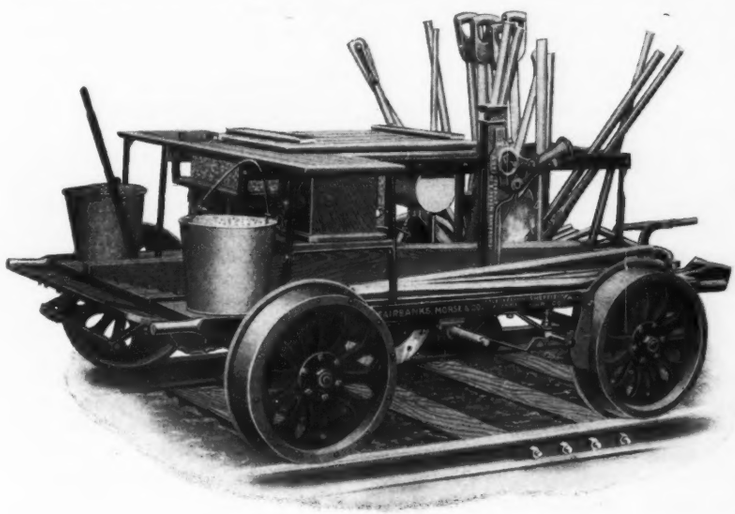
Figure 4 shows a nearer view of the bucket when discharging.



MOTOR CARS FOR RAILROAD WORK.

AN interesting test made this year by George H. Webb, chief engineer of the Michigan Central Railroad, in a No. 16 gasoline motor car, and which is given is full in Fairbanks-Morse Catalogue No. 101A, is of a special interest. The total distance traveled by the car was 4347 miles and the total amount of gasoline used was 231 gallons, or an average of 19.7 miles per gallon of gasoline. The records show that on the run from Jackson to Allegan, a distance of 175 miles round trip, only seven and one-half gallons of gasoline were used, or 23.3 miles per gallon. The total cost per mile including lubricating oil, battery cells and everything excepting wages of man in charge was nine-tenth of a cent. Most any railroad man can figure out that this is quite a saving as compared with a steam locomotive pulling a private car. This gasoline car has its advantages also because of its ability to attain a high rate of speed and maintain it on a long run. From Marshall to Allegan, 66.4 miles, the distance was made in one hour and forty minutes, or at the rate of forty miles per hour, and they report they never stopped the engine once. The distance from Tekonsha to Harris, twenty-nine miles, was made in forty-five minutes, and the best run of the entire trip was made from South Haven to Kalamazoo, a distance of 39.6 miles, in forty-five minutes, or at the rate of 52.94 miles per hour. The manufacturers report that there is a large demand for cars of this class now that they have demonstrated that they are a complete success, and their factory with the present facilities is not able to keep up with the orders which are received from all sections of the country.





INDUSTRIAL ENGINEERING.

CROCKER-WHEELER COMPANY, manufacturers and electrical engineers, announce the establishment of an Industrial Engineering Department, in which is concentrated all their work in the line of industrial engineering as applied to railway shops, machine shops and industrial plants of every description. The company was among the first manufacturers to recognize that even high class electric motors and generators should be accompanied in every case with sound engineering advice to the purchaser. Each sale of a motor has meant with them that a motor-drive problem has been successfully solved by a group of engineering experts. The company are not only "Manufacturers" but "Electrical Engineers."

Among those who have availed themselves of the services of Crocker-Wheeler Company in this line are the Lake Shore and Michigan Southern Railroad, John Simmons Company, Bucyrus Company, Ansonia Brass and Copper Company, American Bridge Company, Pittsburg and Lake Erie Railroad, Joseph Dixon Crucible Company, Ingersoll-Sergeant Drill Company, etc.

J. K. Warner Davenport, E. E., formerly a consulting engineer making a specialty of industrial work, has become associated with the company in order that its growing activities along these lines may be handled in as thorough and satisfactory manner as heretofore.

Mr. Davenport and his staff of assistants are at the present time giving personal attention to several important industrial propositions.

INTERCOMMUNICATING TELEPHONE SYSTEM.

AN interesting development in intercommunicating telephone systems and one which contains many unique and meritorious points is one recently brought out by the De Veau Telephone Manufacturing Company, of New York.

It is immaterial in this system as to whether the receiver is on or off the hook as it is possible to make calls in either position,

DESK SET

also to hold a conversation with several stations at the same time by simply pushing the buttons of the desired stations.

The desk set is of metal and of the same general style as the standard long distance desk set, the buttons being mounted in the base in a circle.

The wall set is equipped with a double row of buttons, the transmitter is of the solid, non-packable type and the receiver is the solid, bi-polar pattern and is non-destructible.

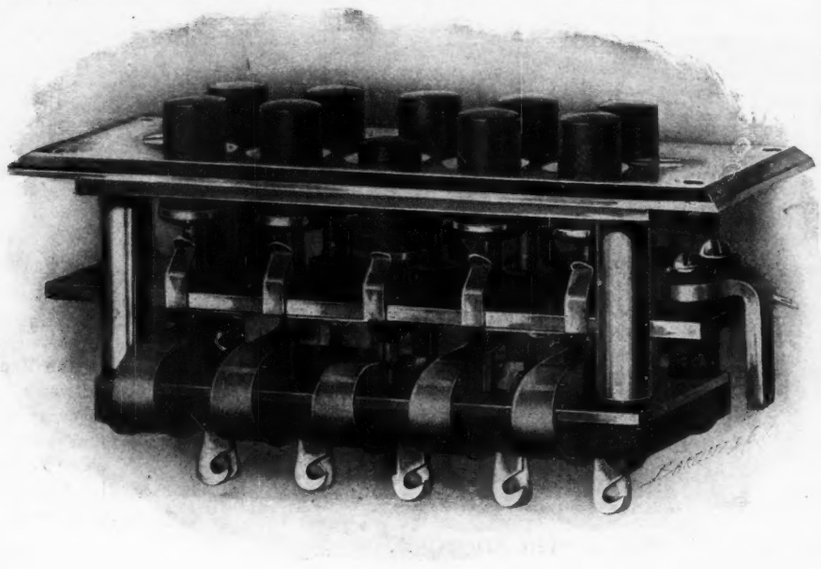
WALL SET

A salient feature of this stem is the automatic restoring of the buttons by hanging up the receiver.

It is claimed that these telephones are as perfect, mechanically and electrically, as high grade material and fine workmanship can make them. All springs are of phospor bronze and the buttons are hard rubber, and being made with diamond tools are absolutely uniform. All connections are soldered and insulated with mica.

These instruments are made up for intercommunicating, centerphone, school, flat and apartment systems.

It is stated that the ordinary wireman can install this system as full wiring diagrams are sent with each telephone.



INTERIOR VIEW

The Standard Electrical Works, 120-130 New Montgomery Street, San Francisco, are the Pacific Coast agents for the De Veau Company, and will be pleased to furnish further information and descriptive matter upon application.

THE YOSEMITE VALLEY AND THE BIG TREES.

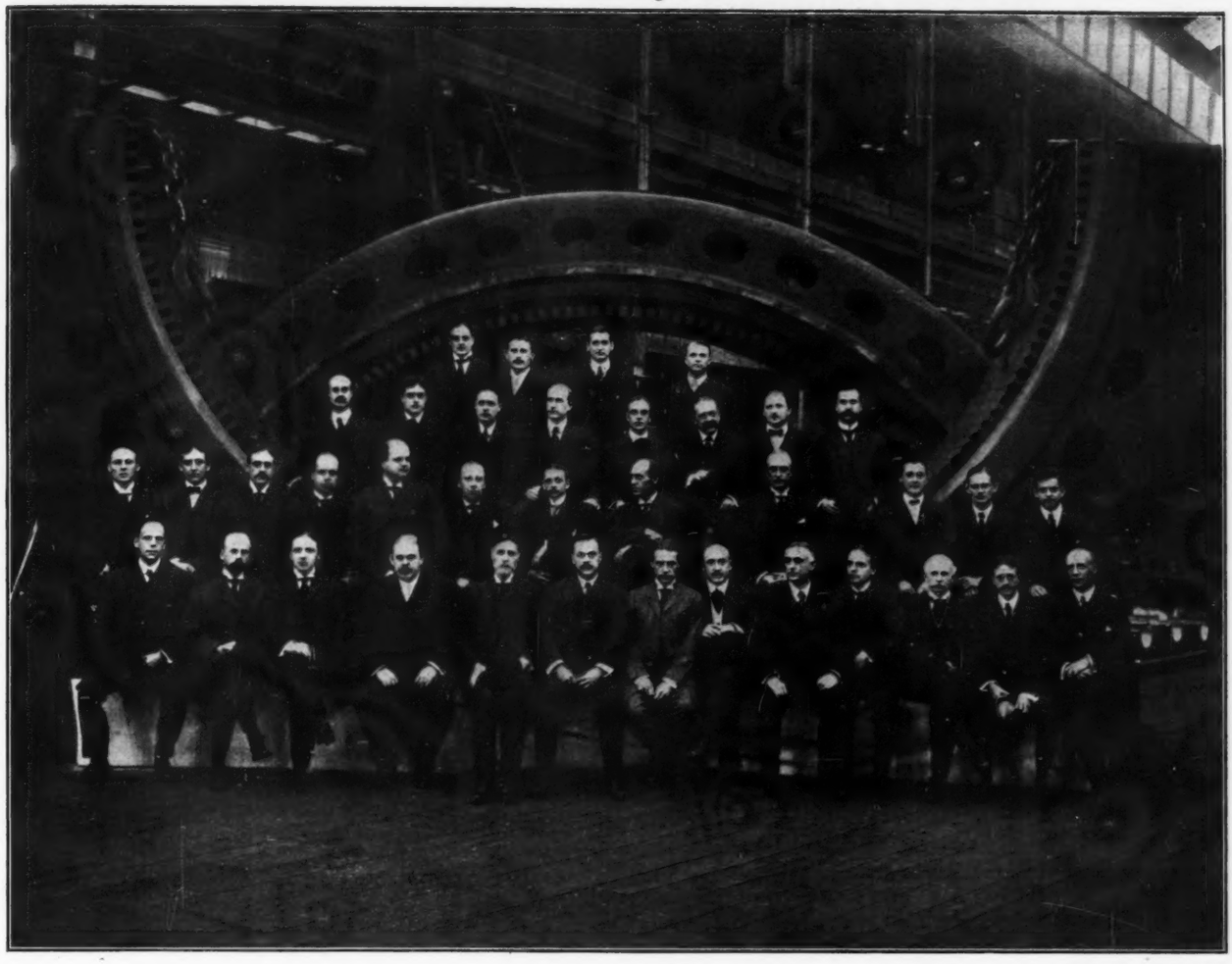
AMOST beautifully illustrated hand book of the Yosemite Valley and the big trees of Mariposa Grove has just been issued

This is a modest little book; but it is wonderful how within its limited compass of forty-eight pages the writer has crammed such a complete mass of descriptive information embracing the practical facts that the tourist and traveler want to know. The reader is taken over the different trails by a capable guide, who clearly describes in due order what may be seen. The value of the booklet is greatly enhanced by two maps of unusual fineness and accuracy and by a wealth of artistic illustration that is scarcely less marvelous than the scenes depicted. The Southern Pacific photographer spent more than two months in the valley and made a large number of studies, from which twenty-eight of the finest have been selected for reproduction, besides four of the Big Trees and one of the memorial building erected in the valley to Prof. Joseph Le Conte. These illustrations and maps are artistic gems worthy of high praise and of the descriptive text.

A five cent postage stamp will bring this from any representative of the Southern Pacific, or its Advertising Bureau, 431 California Street San Francisco.

A very large order for freight elevators was recently closed through the Pittsburg office of the Otis Elevator Company for a single installation of forty-four freight elevators in the new building of the Pittsburg Terminal Warehouse Company, of Pittsburg, Pa. These elevators have a lifting capacity of 6000 pounds and a car travel of about 100 feet.

SAN DIEGO, CAL.—The City Council awarded a street railway franchise to H. A. Howard.



DISTRICT MANAGERS OF THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY

MANAGERS' MEETING.

THE annual convention of the district managers of the Westinghouse Electric and Manufacturing Company was held November 13-16, at the general offices of the company at East Pittsburg. R. L. Warner, New England manager of the company, acted as chairman of the meetings, which were attended by the following representatives of the company:

C. S. Powell, general agent, New York City; W. F. Zimmerman, representative, New York City; Maurice Coster, manager export department, New York City; W. C. Webster, assistant to second vice-president, New York City; F. H. Shepard, New York City; G. Pantaleoni, general southwestern manager, St. Louis; J. R. Gordon, manager, Atlanta; C. F. Medbury, manager, Detroit; H. H. Seabrook, manager, Baltimore; T. J. McGill, manager, Minneapolis; D. E. Manson, manager, Boston; C. A. Bragg, manager, Philadelphia; C. W. Underwood, manager, Buffalo; W. F. Fowler, manager, Pittsburg; T. P. Gaylord, manager, Chicago; D. E. Webster, manager, St. Louis; C. W. Regester, manager, Cincinnati; W. W. Briggs, manager, San Francisco; G. B. Dusinberre, manager, Cleveland; N. P. Randolph, manager, Seattle; J. E. Johnson, manager, Dallas; Paul T. Brady, manager, Syracuse; L. M. Carge, manager, Denver.

At the opening session, which was held November 13th, addresses were delivered by E. M. Herr, first vice-president of the company, by Frank H. Taylor, second vice-president, and by others of the officials. During the four days of the convention papers on topics of general interest were read by many of the fficials and managers and by representatives of allied companies.

The evening of November 15th the delegates and representatives of the local Westinghouse Companies were entertained at the Hotel Schenley by F. M. Herr.

W. W. Briggs, San Francisco, said: "The people on the Pacific Slope are looking forward to a period of uninterrupted prosperity. I believe that the development of interurban railway business has only just commenced, and with the perfection of the single-phase locomotive and the steam turbine, this particular branch of the business will be very much greater than it has been heretofore."

HUNT, MIRK & CO.

HUNT, Mirk & Co., engineers, of San Francisco, report the closing of several recent contracts for plant equipments containing Westinghouse-Parsons turbo-generators.

First—With the Edison Electric Company for the erection of a turbo-generator unit and condensing apparatus. The unit is to be capable of delivering a continuous output of 9000 kilowatts, the generator being a three-phase, fifty cycles and 16,500 volts.

Second—For a complete steam generating plant with the Mt. Whitney Power Company, of Visalia, Cal., which will contain a 1000-kilowatt turbo-alternator.

Third—For a complete steam generating plant with the North Shore Railroad Company which will contain a 1000-kilowatt turbine, direct connected to two 500-kilowatt direct current railway generators.

Purchasers of power plant apparatus on the Pacific Coast are beginning to appreciate the fact that the turbine has arrived, and can no longer be considered as experimental.

KILBOURNE & CLARK COMPANY.

A VIVID idea of the rush of business in electrical and mechanical lines in the Pacific Northwest can be gained by a visit to the establishment of the Kilbourne & Clark Company, jobbers and exporters of electrical supplies, 113 Marion Street, Seattle, Wash.

We very often hear that it is next to impossible to carry a complete stock of electrical supplies and while this is in the main true the Kilbourne & Clark Company have made a praiseworthy effort to attain this ideal condition. Their warerooms are literally filled to overflowing with standard, staple stock and judging from the large number of employees and the general air of hustle around the assembling and shipping departments, this stock only stops for a short period of time en transit from the receiving to the shipping platform. In reply to our question as to the general trade conditions in the Northwest, Dr. E. C. Kilbourne, secretary and manager, replied—"This is supposed to be the beginning of the dull season, but so far we have noticed there has been no let-up in the run of orders, and the present indications are that there will be none, our only trouble is in getting shipments from the East." We assured the Doctor that this condition obtained on the entire Coast, and that slow Eastern shipment was a universal complaint.

The company are representatives and selling agents for a large number of prominent manufacturers and are constantly adding to their lists.

The De Laval steam turbine is one of the high grade productions handled by this company. The steam turbine as a factor in power production is attracting keen attention from engineers and steam users. The De Laval Company claim that the form of turbine produced by them is characterized by great simplicity of construction and that the directness of its energy conversion, producing adiabatic and complete expansion, tend to realize an almost ideal condition.

It is stated that the problem of securing a complete and adiabatic expansion of the steam and the conversion of its entire static energy into kinetic was successfully solved by the De Laval diverging nozzle, and the producing of a wheel accurately enough balanced to revolve about its centre of activity at an enormously high speed without causing a side pressure destructive to plain bearings and a rigid shaft was made possible by the conception of the flexible shaft. Specifications and complete information regarding this apparatus will be furnished by the Kilbourne & Clark Company.

In order to thoroughly cover any and all requirements in the power field, the company have associated themselves with the Watertown Steam Engine Company as general Pacific Coast agents. The Watertown Company are manufactures of a very complete line of steam engines and boilers, the former in both high speed automatic and Corliss types and they state that they make a specialty of engines for electric light and power work.

The shops of this company are equipped with every modern appliance, including steam, electricity and compressed air, and their facilities and location are such that they should be able to turn out a high grade product and ship the same very promptly.

Small electric light installations, or other purposes for which close regulation is a necessity, is a specialty of the Racine Engine Company, Racine, Wis., and they have for years been manufacturing a line of small, upright automatic engines adapted for direct connection or belting, and their product has always been of high standard. Kilbourne & Clark carry various sizes of these engines in Seattle stock ready for immediate shipment.

It is often said that this is the age of the specialist, and the Pittsburg Transformer Company, Pittsburg, Pa., evidently believe that this holds good, not only with the individual but with the manufacturing company, and have made their particular specialty transformers, and a glance through their catalogues is sufficient to convince one that they are bending all their energies and experience to the building of a first-class product. A stock of standard sizes is carried both in the Seattle and the San Francisco warerooms.

The San Francisco offices and sales department are in charge of H. G. Aylsworth, and located in the Rialto Building, and a large stock is carried for this section.

DOERR-MITCHELL & CO.

WHEN R. Doerr first came from the East to Spokane, Wash., some eight or nine years ago, and with J. R. Mitchell organized the Doerr-Mitchell & Co., they inaugerated their business venture in comparatively modest quarters. Mr. Doerr is imbued with an intense fund of energy and has had a wide business experience and this together with Mr. Mitchell's long connection with the Washington Power Company, in the construction department, made an efficient and happy working combination.

Spokane was growing rapidly and flourishing in prosperity, and it was not long ere the firm were forced to seek larger quarters to accomodate their increase in business. Their present headquarters are at 603 Sprague Avenue, where, as dealers, jobbers and importers, they carry a full line of electrical supplies, gas, electric and combination fixtures and show a pleasing display of art fixtures and glassware. In addition to this they also manufacture many of the plainer designs in electric fixtures.

An important branch of Doerr-Mitchell's business is their contracting department, where they are well equipped to take complete contracts for electrical installations from the entrance switches and panel boards to the fixtures and shades. This department has recently finished the wiring of the Masonic Temple Building, a contract which called for some sixteen miles of wire and a large amount of interior conduit, also they have under construction the Spokane Public Library, the Columbia Theatre for over 1000 lights, including the switchboard, dimmers and fixtures complete, the Wonder Department Store and the Seller & Co., establishment, the latter being one of Spokanes largest mercantile houses. With an attractive store, a very complete stock and enjoying the prestige of being the oldest and most entensive fixture and supply house in eastern Washington, Doerr-Mitchell & Co., may well feel that they have contributed very materially to the growth and prosperity of Spokane.

THE "SHERWOOD" INJECTORS.

A DOUBLE-tube or compound injector is an apparatus comprising two sets of jets, one set acting as an ejector, lifting water and supplying same to the second set of jets, which do the forcing or injecting. Any arrangement of this kind produces truly automatic results by working under varying pressures of steam. The injector requires no manipulation after being started although the steam should rise or fall. This cannot be truly maintained for any single-tube injector. Another advantage of the double-tube type of injector is its ability to work water of a higher temperature than a single-tube machine will do. It will also lift water a greater distance. Furthermore, the construction of this machine is such that it is better adapted to handle water heavily charged with mineral matter. These are the advantages of a double-tube injector. For general range of work—hot water, high and low pressure, and long lift—the "Sherwood" Double Tube is the Premier Injector.

The City Council of Gilroy, awarded the California Electrical Works, of San Francisco, the contract for supplies for the construction of the new municipal plant. The contract includes the poles, cross-arms, pole line hardware, weatherproof wire, arc lamps and transformers. The Rio Vista Electric Light and Power Company have also placed a contract with the California Electrical Works for a twenty-five-light, series alternating arc lamp equipment, consisting of lamps, step-up transformer and automatic current regulator.

THE MERGING OF PROMINENT INTERESTS:

FRANK L. BROWN, general manager of the Pacific Steel and Wire Company, and the gentleman who recently successfully put through the Portland Street Railway's consolidation, has just returned from New York where in company with General Victor Enginger and Charles F. Sloane, he has been directing the incorporation of the new Pacific Coast sales agency, The Brown-Spear-Sloane Company in which he is prominently interested.

Mr. Brown reports that the new company has been successfully formed by the merging of the personal interests of Charles F. Sloane with those of Brown-Spear & Co., of which Mr. Brown and Lewis E. Spear, of the Pacific Steel and Wire Company and General Victor Enginger, of the California Wire Cloth Company, are financially interested. The Brown-Spear-Sloane Company have taken the offices recently vacated by the Charles F. Sloane Company, in suite 215 Crossley Building, corner New Montgomery and Mission streets. The officers recently chosen for the administration of affairs are: Charles F. Sloane, president; Lewis E. Spear, vice-president; Victor Enginger, treasurer; and Ralph L. Phelps, secretary.

On November 1st, branch offices were opened in the Pacific Electric Building, Los Angeles, under the able management of Garnett Young, and in the Alaska Building, Seattle, Wash., under the management of Benjamin F. Smith.

Mr. Brown further advises us that this company have recently acquired the exclusive Pacific Coast sales agencies of several very prominent Eastern manufacturers of electrical, telephone and railway equipment, prominent among whom are:

Safety Insulated Wire and Cable Company, Bayonne, N. J., manufacturers of electrical wires and special cables.

American Electrical Works, Phillipsdale, R. I., makers of bare copper and weatherproof wires.

Billings & Spencer, Hartford, Conn., makers of overhead material.

Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., complete telephone equipments, switchboards, telephones, cables and telephone supplies.

Hart and Hegeman Manufacturing Company, Hartford, Conn., manufacturers of the celebrated Hart switches for lighting circuits.

Osborn Flexible Conduit Company, New York, originators and manufacturers for the flexible conduit, known as "Flexduct."

National Metal Moulding Company, New York, manufacturers of "Economy" iron armored conduit.

Pass & Seymour, Inc., Solvay, N. Y., electrical specialties and porcelain of special design.

Crouse-Hinds Electrical Company, Syracuse, N. Y., all copper switches, switchboards and railway headlights.

Morden Frog and Crossing Works. Chicago, Ill., electrical and steam railroad track material.

Hemingray Glass Company, Covington, Ky., glass insulators and glass of special design for overhead transmission.

With their sales department fully equipped to handle anything in the electrical, telephone and railway activities, they are soliciting the trade in general in the interest of the above company which they represent.

The gentlemen interested have extended a most courteous invitation to all those interested in electrical developments to make their offices either in San Francisco, or their branch offices in the other cities, headquarters while in town. In these offices will be found complete sample displays of each company represented, and the Brown-Spear-Sloane Company will be able to make immediate Pacific Coast deliveries from their complete stocks warehoused in Los Angeles, San Francisco and Seattle.

STANDARD UNDERGROUND CABLE COMPANY.

This company has recently opened a sub-office in the Northwest located in the Exchange Bank Building, Spokane, Wash. This branch office will be in charge of F. E. Hoar who, for some time past, has traveled the Northwest territory for the Standard e Company.

AN IMPORTANT PELTON CONTRACT.

AS indicating the enormous strides being made in hydro-electric development, a recent order for Pelton water wheels is very significant.

The California Gas and Electric Corporation has closed a contract with the Pelton Water Wheel Company for a 10,500 horsepower water wheel unit to be located at the Deer Creek station, forming a part of their vast system of electric distribution. This establishes a record, as there has never before been built an impulse wheel of such great capacity. The unit in question is to operate under an effective head of 765 feet and will be direct connected to a 5500-kilowatt 300 revolutions per minute generator. The "double overhung" type of construction, which is typical of Pelton apparatus, will be employed, and the unit will consist of two Pelton wheels, one mounted on each overhanging end of a single shaft which carries the rotor of the engine type generator.

Some idea of the magnitude of this unit will be gained by noting that the rotor of the generator will weigh in excess of 45,000 pounds, and will be carried by a hollow nickel steel shaft twenty inches in diameter. This implies very severe strains on the moving elements, and the journals and supports are correspondingly heavy. The wheel centers will be of disc construction of open hearth cast steel, and fitted with steel buckets secured to the rim by means of turned steel bolts hydraulicly pressed into reamed holes. All pressure parts, such as gates, nozzles and connections will be of cast steel. The gate valves, of the single disc Pelton type, will be provided with roller bearings to take the thrust from the nickle steel spindles, and the valves will be normally operated by electric motors with provisions for hand control when necessary. But a few years ago 1000 horsepower was considered as the limit of capacity for an impulse wheel, and the contrast with the present equipment is most striking.

The Pelton Water Wheel Company report having closed a contract with the Vancouver Power Company, of Vancouver, B. C., for another large water wheel, this consisting of a 3000 horsepower Pelton unit of the "double overhung" type, direct connected to a 1500-kilowatt 200 revolutions per minute generator, operating head being 390 feet. In 1903 the Pelton Company furnished three units of exactly similar construction and capacity for this same company, and the power house is arranged for the reception of the two additional units, providing for a total overload capacity of 15,000 horsepower.

In addition to the water wheel equipment, the Pelton Water Wheel Company has received a contract for the pipe line, consisting of approximately 1050 feet of pipe, varying from forty-eight inches diameter, nine-thirty-second inches, forty-two inches, seventeen-thirty-second inches in thickness. This pipe is furnished from the Eastern works of the company, and the contract calls for the material delivered and installed in place.

The Columbus Consolidated Mining Company, of Utah, has duplicated its order for a 750 horsepower Pelton wheel, the original of which was installed two years ago, while the United Light and Power Company, of Georgetown, Cal., is installing another 1000 horsepower Pelton unit, this being the second order received from the above company within the last three years.

The Fremont Power Company, of Washington, has ordered two Pelton wheels for direct connection to a 400-kilowatt generator.

A recent contract with the Northwest Light and Power Company of North Yakima, Wash., covers a Pelton unit for driving a 350-kilowatt generator.

The Westinghouse Electric and Manufacturing Company are doing a large business in equipping mines with electric locomotives, to replace the older forms of haulage, whether animal or mechanical. Electric mine haulage considered from either the points of efficiency or economy has so many advantages, as compared to the older practice, that the time is not far distant when any other method of mine haulage will be the exception.

THE AMERICAN WOOLEN COMPANY.

THE American Woolen Company, of Boston, Mass., through their president, William M. Wood, has just signed a contract with the Otis Elevator Company, of New York, for four escalators to be installed in the new "Wood" worsted mill which is being built at Lawrence. This is the first factory installation of the escalators on record and in fact one of the first instances where provision has been made in a factory equipment for mechanical means of elevating employees from the surface level to the various floors.

The "Wood" worsted mill will be one of the largest single factory buildings in the world, contemplating an ultimate capacity of 5000 hands. The escalators are to be installed in a special building situated between the wings of the factory proper and adjoining and connected with the factory entrance which is at the second floor, it being contemplated that employees shall either walk down from the fourth to the third floor or ascend by ordinary stairs from the second to the third floor. One escalator will run from the fourth to the fifth floor and one from the fourth to the sixth floor.

Although this escalator installation involves an investment of approximately $100,000, it is calculated by the management of the American Woolen Company that the enhanced efficiency of the employees will more than offset the interest on the investment, most of the employees being women and the injurious effects of stair-climbing upon women being recognized as more serious than the mere consumption of muscular effort.

It is contemplated that not only will the operatives useful effort be conserved by the installation of the escalators but that on account of the absence of laborious stair-climbing this factory will have the choice of operatives of the vicinity.

To distribute without delay to their respective floors so formidable an army of workers as will be housed in the new "Wood" mill will, naturally, require a tremendous elevating capacity. It is estimated that 100 ordinary elevators would be required to equal the equipment represented by four escalators. The escalators will be run in a downward direction just prior to, and for a short time after the noon whistle, and in similar manner at the closing hour at night, also in the event of fire or other panic. At all other times they will be run in an upward direction. The feature of instant reversibility and the fact that the escalator acts as a constant carrier without attendance will insure in the event of serious panic the delivery to the street level of anyone who can reach or be helped to the escalator even though such individual was unconscious during transit.

It should be interesting to calculate and observe what will be the actual result of an escalator installation of this magnitude in a factory of this character from a "social welfare" point of view.

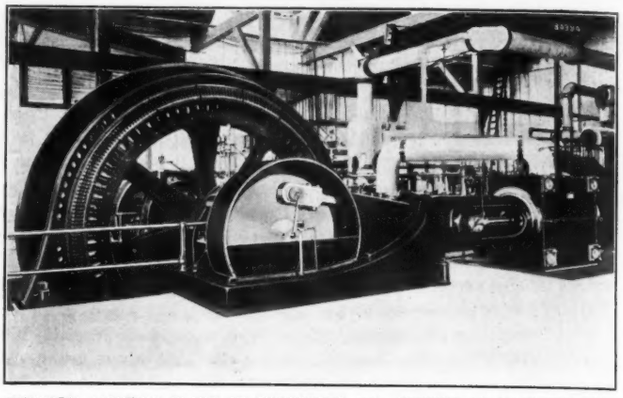
THE ELECTRIC STORAGE BATTERY COMPANY.

A CONTRACT recently closed by The Electric Storage Battery Company with the Spokane and Inland Railway Company, Spokane, Wash., forcibly illustrates the flexibility of the storage battery and its adaptability to meet special conditions. In this instance the battery is installed to regulate the fluctuations of a single-phase railway load. Power is purchased as three-phase, sixty cycle current from the Washington Water Power Company on the maximum demand basis, and delivered, through motor generator sets, to the single-phase line. Each motor generator set will be provided with a direct current machine mounted on the same shaft and connected to the terminals of the battery circuits.

The battery charge and discharge will be effected by two boosters in the battery circuits operating in parallel with each other, each having a capacity equal to one-half the maximum output of the battery. These boosters will be controlled by The Electric Storage Battery Company's carbon regulator, which in this case will be made responsive to fluctuations of the alternating current supply, thus causing the battery to keep those fluctuations within narrow limits.

LIGHTING THE CITY OF ALPENA.

THE City of Alpena, Mich., which recently voted an issue of bonds to defray the cost of a municipal lighting plant, has contracted with Allis-Chalmers Company, of Milwaukee, for the complete electrical and power equipment. This consists of a sixty-cycle Bullock alternating current generator, normal capacity 150 kilowatts, direct connected to a Reynolds-Corliss



MUNICIPAL LIGHTING PLANT AT OWNESBORO, KY., SHOWING AN ALLIS-CHALMERS GENERATING UNIT SIMILAR TO THAT CONTRACTED FOR BY THE CITY OF ALPENA, MICH.

cross compound heavy duty engine; an exciter unit; jet condenser; switchboards; substation apparatus, and equipment for 100 arc lamps connected in series. A feature of this installation will be its compactness, as provision has been made for the future enlargement of the plant, when the growth of the city demands it, by an extension of the existing building and the addition of another generating unit.

THE NORTHWEST ELECTRIC ENGINEERING COMPANY.

THIS well known Portland concern has outgrown their present quarters at 309 Stark Street, and will remove January 1st to the new Elks Building, situated on the corner of Seventh and Stark streets, where they will have commodious ground floor showrooms and offices. They are North Pacific Coast agents for the following well known specialties: General Incandescent Arc Light Company's arc lamps; Northern Electric Manufacturing Company, motors; Prometheus Electric Company, New York, heating apparatus; Phelps Hylo Lamps and Flash Sockets; Russell & Tomlinson Co's. full line of telephones; Stanley G. I. Company, generators. They are also contracting and electrical engineers and make a specialty of complete light and power installation. The officers are D. A. Paine, president; G. W. Handsaker, vice-president and treasurer; Henry C. Shade, secretary and manager.

CASCADE GAS AND ELECTRIC FIXTURE COMPANY.

AMONG the enterprising firms who realize the benefits to be derived from the operation of their own factory is the Cascade Gas and Electric Fixture Company, 214-218 Cherry Street, Seattle, Wash. This company manufacture a very complete line of electric, gas and combination fixtures, many of which are of their own special design. They are making a special effort to secure the trade of the dealers in the Northwest and feel that with their splendid manufacturing facilities and expert designers that they are in a position to handle this particular trade. The Cascade Company have issued an attractive catalogue covering their standard line, but state that they will at all times gladly submit designs for fixture requirements which cannot be selected from this catalogue. Designs, printed matter and prices will be promptly forwarded to interested parties upon application to the above address.